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Precision Marksman/Observer Manual

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DEPARTMENT OF HOMELAND SECURITY

UNITED STATES BORDER PATROL
SPECIAL OPERATIONS

PRECISION MARKSMAN/OBSERVER MANUAL

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NOTICE TO THE READER

This manual should be thought of as a living document in that it will continue to evolve as knowledge is gained through training and experience. It will be periodically updated as tactics, techniques, and equipment in the Precision Marksman/Observer field change over time.

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THE PM/O CONCEPT

INTRODUCTION

The U.S. Border Patrol Special Operations Precision Marksman/Observer (PM/O) is a specially selected, specially equipped, and highly trained team member who uses his training and equipment to obtain a position of tactical advantage, provide real time information to other elements of the team, and if necessary, bring precision fire against a threat that cannot be successfully or tactically engaged by other tactical team members.

MISSION

The mission of the Special Operations PM/O is to provide an enhanced tactical response capability through a tactically superior operating position that allows the tactical commander an observational and ballistic advantage beyond a suspect's ability to control.

An *enhanced tactical response capability* refers to the enhancement of the tactical team through the use of specially trained and equipped individuals acting as PM/Os.

A *tactically superior operating position* is a location that allows for clear observation of the threat area so the PM/O can communicate real-time intelligence, and provides a stable shooting platform should it be necessary for the PM/O to engage a threat.

The *observational advantage* is the PM/O's ability to gather critical information through superior positioning, optics, and concealment.

The *ballistic advantage* refers to the PM/O's ability to deliver precise, controlled fire with sufficient kinetic energy to neutralize a threat immediately. This may require the penetration of medium such as glass, wood, or body armor.

Beyond a suspect's ability to control means that a suspect may be able to act against a tactical assault team, but by virtue of the superior operating position, the suspect cannot directly control or act upon the PM/O. In conjunction with other perimeter control elements, the PM/O limits the ability of a suspect to maneuver and places the suspect within a restricted area that the tactical team can control.

TRAINING

The PM/O's training involves a wide variety of subject matter and practical skills. These skills focus on marksmanship and field craft, resulting in the ability to move undetected to a forward operating position.

Training should be conducted as realistically as possible and in all weather and lighting conditions. PM/Os should practice engaging moving targets, shooting from various positions (conventional and unconventional), constructing operating positions (rural and urban), and moving into position.

It is the responsibility of the PM/O to maintain well-kept training records. Training conditions such as weather, temperature, altitude, ammo lot number, etc., as well as the PM/O's performance under those conditions should be recorded in a data book.

USE OF FORCE

The Special Operations PM/O engages threats in accordance with the Federal Law Enforcement Training Center Use of Force Model, which is the standard by which the United States Border Patrol judges the amount of force authorized to be used against a subject *(See Attachment 5)*. He will use deadly force only against those threats that can be positively identified and display the elements of Means, Opportunity, and Intent to inflict death or serious bodily harm or injury to another.

In most cases, the decision to use deadly force will be based on the PM/O's own discretion. The PM/O's authorization to use deadly force is no different than that given to any other agent. The PM/O must have probable cause to believe that the suspect has committed a felony involving the infliction or threatened infliction of serious physical injury or death, that the escape of the subject would pose an imminent danger of death or serious physical injury to the PM/O, another agent or officer, or another person, and that deadly force is reasonably required to prevent the suspect's escape; or the suspect must pose an immediate threat to the life of the PM/O, the life of another agent or officer, or the life of another person. The PM/O must also be able to identify with reasonable certainty the suspect from among other individuals present.

There are rare situations when the PM/O may have all the requirements present to use deadly force, but because of some extenuating circumstances the shot may be too risky. A gunman who has taped the muzzle of a shotgun to a hostage so that it will fire if the gunman is shot or assaulted is just one example of such a situation. The PM/O may have to rely on the tactical commander for this information.

On the contrary, there are also situations where the PM/O may not perceive the suspect to be an immediate threat, but the tactical commander has information about the immediate threat the suspect poses. In this type of situation the tactical commander may authorize the PM/O to use deadly force. With this type of authorization the PM/O may shoot as long as he can identify the suspect with reasonable certainty.

Acting under the tactical commander's discretion in no way implies that the legalities or standards regarding the use of deadly force are relaxed in any way. The tactical commander is assuming responsibility for the PM/O's use of deadly force based on the tactical commander's knowledge that the suspect has fulfilled the agencies requirements for the use of deadly force. The PM/O is in no way relieved from making independent decisions regarding the use of deadly force.

MARKSMANSHIP FUNDAMENTALS

INTRODUCTION

The Special Operations PM/O must be extremely proficient in basic marksmanship skills. Although many skills are required of the team PM/O, mastering the fundamentals of shooting is without a doubt the most important. The surgical bullet placement required for a hostage crisis resolution, or the long-range shooting required for engaging hostiles in a desert environment allow little room for shooter error. Since so many variables play a part in bullet flight, the team PM/O must eliminate the variables that he has the most control over.

STABLE SHOOTING PLATFORM

Butt of Rifle Stock

The butt of the rifle stock should be placed firmly in the pocket of the firing shoulder. By placing the butt on the end of the pectoral muscle, the recoil energy is dispersed over the large muscle area, making recoil more tolerable.

When lying in a prone position, the butt of the weapon will be resting on the collarbone, where the collarbone meets the shoulder. A shoulder pad and/or a good recoil pad will help absorb the recoil. It will also help prevent slippage and reduce the affects of pulse beating and breathing, which are transmitted to the weapon.

Stock Weld

Stock weld refers to the placement of the shooters face against the stock of the rifle. The cheek should be placed in the same position on the stock every time the shooter fires the weapon. A change in stock to cheek weld will cause improper sight alignment, resulting in a misplaced shot.

To find the proper stock weld, look through the scope of your rifle and have a partner look through the other end of the scope. The crosshairs of the scope should intersect the center of the pupil of your eye. A cheek pad may need to be added to the rifle stock so that your cheek can rest in the proper position.
Once your cheek weld has been determined, a “kisser” button can be taped onto the stock to help ensure proper cheek placement. The button should be positioned so that it touches the corner of your mouth when you have a proper stock weld.

Elbows

The shooter should find a comfortable position that provides the greatest amount of support. Elbow pads or a shooting mat will make the elbows more comfortable and will also aid in support.

Non-firing (Support) Hand

When the fore end of the stock is supported on a bipod or field expedient support (i.e. rucksack or sand bag) the non-firing hand is used to support the butt of the weapon. The hand is made into a fist and placed thumb up next to the cheek and underneath the rifle butt. The tip of the butt is rested on the fist. The rifle butt can then be raised or lowered by squeezing or loosening the fist. A sock or bag filled with sand or rice can be used in the same fashion. Using a squeeze bag reduces body contact with the weapon, thereby reducing the affects of body rhythms and muscle fatigue.

Firing Hand

When using a bolt-action rifle such as a Remington 700P, the shooter grips the small of the stock behind the receiver with the thumb on top of the stock and the fingers on the bottom. When using a rifle with a pistol grip such as an M4, the shooter grips it the same as he would a pistol. The thumb and last three fingers should hold the weapon, but not so tightly as to loose the delicate feel of the trigger. The firing hand should not be used to control the rifle, but to manipulate the trigger and cycle the bolt when necessary.

Trigger Finger

The index finger is placed as low on the trigger as possible to give the shooter the best mechanical advantage. The trigger should contact the middle of the first pad of the finger, between the first knuckle and the fingertip. When pulling the trigger, the finger should travel straight back toward the butt of the rifle.

Bone Support & Muscle Relaxation

Any strain or tension on the muscles will cause the shooter to tremble. This trembling will transfer to the weapon, making it difficult to hold the crosshairs steady on the target. To avoid this problem the shooter must use as few muscles as possible to hold his position. Bone support provides a firm foundation for the weapon and allows the muscles to be relieved of stress and weight.

Natural Point of Aim

A natural point of aim is one that allows the body to remain relaxed behind the rifle without having to strain to acquire a sight picture. The benefits of a natural point of aim are that the shooter can remain on target for a longer period of time, can achieve consistent accuracy, and can get back on target quicker after cycling the bolt.

To test your point of aim, settle in behind the rifle and aim in on a target. Close your eyes and take a few deep breaths and relax. Open your eyes. If you are still on target at your intended point of aim, or at least very close to it, then you have found a natural point of aim.

AIMING

Eye Dominance

To determine which eye is the dominant eye, extend one arm forward and make a circle using the thumb and index finger. Finds a point and center it in the circle. Close one eye, then the other. The eye that has the object centered in the circle is the dominant eye.

Some shooters may be cross-eye dominant. This means that the shooter shoots right-handed, but has a dominant left eye or visa versa. This can be remedied by either firing from the other side of the weapon, or by closing the non-dominant eye when looking through the scope.

Eye Relief

Eye relief is the distance between the aiming eye and the rear of the scope tube or sight. When using iron sights the shooter should make sure that the distance remains consistent from shot to shot. Eye relief will vary according to the individual and firing position. The length of the shooter's neck, the angle of his head on the stock, the depth of his shoulder pocket, and his firing position will dictate the amount of eye relief.

Eye relief is more rigidly controlled with telescopic sights. The head should remain as upright as possible to avoid strain on the eye muscles. Eyestrain will cause the eyes to become fatigued, resulting in blurred vision.

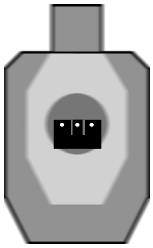
The eye should remain far enough away from the scope to avoid being struck during recoil. A distance of between two to four inches between the eye and the scope is ideal. Any presence of crescent shadows indicates improper eye relief. The best way to ensure proper eye relief is to maintain the same stock weld from shot to shot.

Sight Alignment

Sight alignment is the relationship between the front and rear sight as seen by the shooter. The shooter centers the top edge of the front sight blade vertically and horizontally within the rear aperture. If using a blade-type rear sight, the top of the front sight blade should line up with the top of the rear sight.

With a telescopic sighting system, sight alignment is the relationship between the reticle and the scope tube. A proper sight picture will result in a clear reticle centered in a full field of view. Shadows around the reticle are indicative of improper sight alignment and can be a result of improper eye relief or improper stock weld.

Sight Picture



Sight picture refers to how the shooter sees the sights and the target in relationship to each other. The top edge of the front sight post is centered on the desired point of impact and the sights are properly aligned. The front sight should be in focus while the rear sight and target remain slightly out of focus.

When dealing with telescopic sights, the same concept applies except that the scope brings all three elements into the same focal plane. The point where the crosshairs meet is centered on the desired point of impact.

Sometimes when viewing through a scope the reticle may appear to shift in relation to the target, indicating that *parallax* is present. Parallax is a result of the reticle and image in the scope being on two different focal planes. Keeping the aiming eye well centered can minimize parallax error. The magnification of a variable power scope can be adjusted to assure maximum image sharpness and eliminate the potential for parallax error.

Sun Glare

Although not a factor of aiming per se, sun glare can cause problems during aiming. When the sun or another bright light shines into the objective lens of a

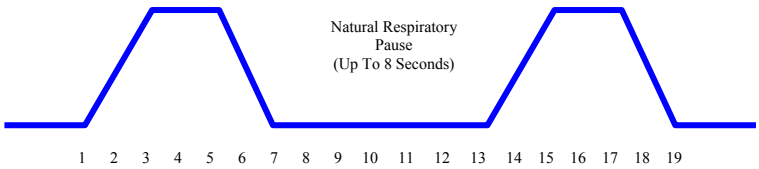
scope, the edges of the reticle wires reflect the light causing the opposite sides of the reticle wires to look dark. This may cause the shooter to shift the scope resulting in a misplaced shot. Using a screen or sunshade on the scope can prevent Sun glare. Camouflage netting can be placed over the scope and will not interfere with operation.

Sun glare can also be a problem with iron sights. The surface of the front sight post becomes reflective once the finish has worn down. When the sun reflects off of the sight post the top of the post will appear to be lower that it actually is. This will cause the shooter to aim high. To prevent this from happening, the front sight post should be darkened periodically. Flat black model paint works well for darkening the sight post. In a pinch, permanent marker, camouflage face paint, or even shoe polish can be used to darken the sight post temporarily.

BREATHING CYCLE

Breath control is an important part of aiming. When the shooter breaths, his lungs and chest expand and contract causing movement behind the weapon. If breathing is not properly controlled, the weapon will move and cause the round to impact the target at a location other than the desired strike point.

The average breathing cycle consists of about two seconds of inhalation, two seconds of exhalation, and a *natural respiratory pause* at the bottom of the cycle, which lasts for about two to three seconds. This pause can be extended up to eight seconds without any ill affects.



To take advantage of the natural respiratory pause, the shooter should inhale, exhale, pause, and then squeeze the trigger during the pause. When engaging multiple targets or executing rapid shots the breathing cycle should be forced using a rapid, shallow breaths between shots. Attempting to hold the breathing cycle for too long or between multiple shots will cause muscle tension and can adversely affect shot placement.

HEART RATE

The best way to minimize the adverse affects of the heart beating is to stabilize the rifle

on a firm base. A sand bag, bipod, rucksack, or other field expedient rifle support will hold the rifle steady and will help absorb movement and vibration caused by heartbeats and breathing. A recoil or shoulder pad between the rifle and shooter minimizes transference between the shooter and rile.

Aerobic conditioning strengthens the heart and increases the efficiency of the muscle. A strong heart will pump more blood on a single beat, thus reducing the number of times per minute that the heart needs to beat. Slow deep breaths will help the body relax during times of anxiety or stress, thereby slowing the heart rate and calming the shooter.

TRIGGER CONTROL

Trigger control is defined as the rolling back on the trigger in such a fashion as not to disturb the sight picture when the shot is fired. This is accomplished by using the last pad of the trigger finger to pull the trigger straight back in a rolling fashion by slowly increasing the amount of pressure. Timing and smoothness are the keys to trigger control.

Trigger control is the single most important shooting fundamental. Improper trigger control will cause the bullet to strike low and off to the side.

FOLLOW THROUGH

Follow through refers to the continuation of applied marksmanship fundamentals as the weapon fires and immediately after it fires. It ensures that the weapon fires and recoils naturally, allowing the PM/O and the weapon to react as a single unit. Proper follow through consists of maintaining a good stock weld, holding the trigger rearward through the shot and then releasing it slowly after recoil stops, maintaining a good sight picture, keeping a natural point of aim, and avoiding reaction to noises.

SHOOTING POSITIONS

A good shooting position is one that provides bone support, offers muscle relaxation, and allows for a natural point of aim. It should be reasonably comfortable and offer a good range of mobility. The closer the weapon is to the ground, the steadier the shooting position will be.

There are four basic shooting positions that every PM/O should be familiar with. There are several variations of these positions, all of which may be supported or unsupported.

Prone Position

The prone position is the easiest position to assume, provides a low silhouette, adapts well to cover and concealment, and is the most stable position.

Supported

The fore end of the rifle is supported by a bipod, sandbag, or other field expedient support. The butt of the rifle is tucked into the shoulder and is supported by the non-firing hand and perhaps a squeeze bag. The small of the stock is grasped by the firing hand, and the firing elbow is lowered to the ground so that the shoulders are level. The shooter's body should be positioned well behind the rifle to absorb recoil. The legs can be spread with the ankles flat on the ground, or the firing-side leg can be cocked and the shooter can roll over onto the support-side leg, assuming what is called a *rollover prone position*.

Traditional Prone Position

Rollover Prone Position

Unsupported

This position is essentially the same as the supported prone position. Bone support is achieved by placing the non-firing hand under the fore end of the rifle with the elbow resting on the ground. Either the straight leg or rollover position can be used in the unsupported prone position.

Seated Position

Supported

The supported seated position is assumed by supporting the fore end of the rifle on a bench, table, or other elevated structure. A bipod or other field expedient support should be placed between the fore end and the structure. The shooter sits directly behind the weapon and positions his hands and elbows the same as he would in a supported prone position. This position is most likely to be used when firing from inside a building or from a bench rest.

Unsupported

The unsupported seated position is assumed by sitting down on the ground, crossing the legs, bending forward, and resting the elbows in the pockets of the knees. Bone support is obtained by ensuring that the non-firing elbow and wrist are straight under the fore end of the rifle and that no bone on bone contact is made with the knees and elbows. The body is aligned approximately 45-degrees from the target. This position requires some flexibility and is difficult to hold for very long.

There are two other variations of this position. One variation is to cross the ankles. The other variation is to keep the legs open wide apart. Neither of these positions is as stable as the crossed leg position, but they do have their own tactical applications.

Crossed Ankle Position

Legs Open Position

Kneeling Position

Supported

The kneeling position is performed by placing one knee on the ground and leaving the other leg upright with the foot flat on the ground. The shooter can either kneel upright or can sit on the foot of the kneeling leg. The fore end of the rifle is supported using an elevated structure, or by using a rigid object such as a tree or post to support the rifle.

Unsupported

This position is the same as the supported kneeling position except that the rifle is supported by placing the non-firing hand under the fore end of the rifle and resting the triceps of the non-firing elbow against the elevated knee.

Standing Position

Supported

The supported standing position is simply a normal standing position with the fore end of the rifle rested against an elevated structure or rigid object.

Unsupported

This is the most unstable firing position. It should only be used when no other alternative exists.

SLINGS

Loop Sling

The sling is released from the butt of the weapon and a loop is formed which slips over the shooter's support arm just above the bicep. The loop is tightened around the bicep by pulling down the keepers or buckle. The forward loop of the sling can be adjusted to shorten the sling as needed. The support hand is inserted between the sling and the forearm of the weapon to support the front of the rifle.

The loop sling offers the most stability, but is not suitable for long-term operations. Using a loop sling for too long will reduce blood flow to the arm.

Hasty Sling

With the sling in place on the rifle, the shooter inserts his support arm through the sling, past the elbow. The support arm is then brought back around the sling and the support hand is inserted between the sling and the forearm of the weapon to support the front of the rifle. The support hand is pulled back until the sling tightens. If the hand comes too far back, then the sling needs to be tightened.

INTEGRATED ACT OF FIRING

The integrated act of firing is a step-by-step sequence that allows the PM/O to develop good habits that will help him fire each shot consistently. It is divided into four phases:

Pre-deployment Phase

Before leaving the preparation area, the PM/O should make a systematic check of all equipment to make sure that it is cleaned, serviced, and ready for operation. Current weather conditions should be studied to determine any possible affects on the PM/O's performance and mission. A thoroughly kept data book should accompany the PM/O on each deployment.

Pre-firing Phase

Upon arriving at the mission site, the PM/O must select an operating position that supports the mission. Once in position, the PM/O will check the field-of-view and field-of-fire and will make needed corrections to ensure an unobstructed firing lane, taking into consideration cover, concealment, and other officers or bystanders in the line of fire. The PM/O may then set up a shooting mat, sandbag, rifle, and any other tools or equipment he may want accessible.

Proper sighting adjustments are made on the weapon system according to the current temperature, altitude, range, wind direction and velocity, and slope angle. These conditions should be checked periodically for any changes.

Firing Phase

Aim

The PM/O ensures that he has a natural point of aim so that the rifle points at the target during the respiratory pause. If the aim is off, the PM/O should make slight adjustments to acquire the desired point of aim.

Relax

Relaxing as many muscles as possible will help the PM/O to focus and stabilize the weapon. During this phase, the PM/O checks for consistent head placement on the stock weld and correct eye relief.

Breathe

The PM/O inhales and exhales to the natural respiratory pause.

Aim Again

It is at this stage, during the natural respiratory pause, where the PM/O takes his final aim at the precise point where it is desired for the round to impact the target.

Squeeze

The trigger is squeezed straight to the rear without disturbing the sights or the position of the rifle.

Recovery Phase

During the recovery phase, the PM/O utilizes a proper follow through. He then prepares for a follow-up shot in case his shot did not effectively neutralize the target, or to address other targets if needed.

SHOOTER ERRORS

Analyzing the shot group during training can help identify possible shooter errors. The following are the most common shooter errors and their possible causes:

Group Low & Right

Caused by improper trigger control, an improperly positioned support hand, or a slipping firing hand elbow. Shots will be low and left for a left-handed shooter.

Group Scattered

Caused by incorrect eye relief or sight picture, an improper stock weld, loose scope mounts, or an unstable firing position.

Good Group with Erratic Shots

Caused by flinching or jerking due to recoil anticipation.

Group Vertically Strung

Caused by breathing while firing or changing the stock weld. This may also be caused by improper barrel to fore end clearance. If there is not at least 1/32 of an inch clearance between the barrel and fore end, then the weapon must be sent to an authorized gunsmith for repair.

Group Horizontally Strung

Caused by canting the weapon, an incorrect point of aim, or scope shadow.

Tight Group Off Target

Caused by an incorrect zero, poor wind compensation, an incorrect point of aim, or scope shadow.

RANGE ESTIMATION

INTRODUCTION

Accurate range estimation is a critical function of the PM/O. All of the calculations and corrections for windage, elevation, and lead are based on the distance to the target. Incorrect range estimation can result in a misplaced shot and a failed mission to say the least.

This section will explain a number of different techniques that can be used to estimate range. None of these techniques should be used exclusively. The PM/O should use two or more different techniques to arrive at the estimated range. This will ensure an accurate estimation by providing the PM/O with checks and balances.

FOOTBALL FIELD METHOD

The football field method is a simple way of measuring distances out to about 1,000 yards. The shooter estimates the number of football fields that could fit within the given distance and then multiplies by 100. For distances beyond 500 yards, the shooter must find an object half-way between him and the target, determine the number of 100-yard increments, and then double the distance.

100-METER/YARD METHOD

To use the 100-meter/yard method the shooter must be able to visualize a 100-meter/yard distance on the ground. Like the football field method, the shooter estimates how many 100-meter or 100-yard increments lie between him and the target. For distances beyond 500 meters/yards, the shooter must find an object half way between him and the target, determine the number of 100-meter/yard increments, and then double the distance.

AVERAGE METHOD

The average method takes the average between two estimated ranges to the target. For example, if the shooter estimates the distance to target as 200 yards and the observer estimates the distance to target as 150 yards, the two distances are averaged to equal 175 yards.

BRACKETING METHOD

The bracketing method is the simplest of all the ranging methods. It is accomplished by assuming that the target is no farther than *X distance*, but is no closer than *Y distance*. The X and Y distances are then averaged, resulting in the estimated distance to the target.

OBJECT APPEARANCE METHOD

The object appearance method uses the known size and characteristic details of an object to determine the approximate distance to a target. In order for this method to be effective, the PM/O must be familiar with the physical characteristics of different objects as they appear at various distances.

COMPARISON METHOD

Many of today's modern subdivisions are designed uniformly with each lot and house being roughly the same size. Knowing the lengths of houses, lots, and blocks, within the subdivision where a target is located can aid the PM/O in accurate range estimation.

For example, if each block within the subdivision where the target is located is 200 yards long, and a threat appears in front of a house that is in the middle of the block, the range to the target would be 100 yards.

If the lengths of features within a uniform subdivision are not already known, then the PM/O can pace-count as he moves through the neighborhood to his operating position. The PM/O may also be able to go to an adjacent block or similar neighborhood prior to the mission in order to study the layout and determine ranges and fields or fire.

MAP DISTANCE METHOD

The distance to a target can be accurately determined using a map of the target area. Once the PM/O has identified the location of his position on the map, he can then determine the distances to various features of the target area by using the map legend. This will aid in judging the distance to a threat that appears within the PM/O's field of fire.

During rural operations the PM/O can obtain U.S. Geological Survey maps. These 1:24,000 scale maps are accurate to within 10 meters (11 yards), and can aid in range estimation, land navigation, and PM/O position selection.

Survey maps can be acquired from most city and county records offices in urbanized areas. These maps contain overhead views of neighborhoods, as well as property lines and addresses. They also have a scale showing the distances between houses and other land features. These maps are quite useful during urban operations and are accurate to within a few feet.

GPS METHOD

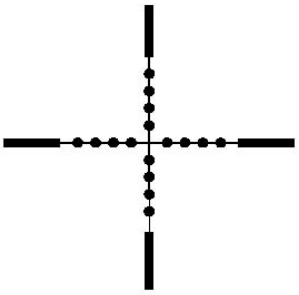
The GPS method is similar to the map distance method in the sense that the PM/O must know the coordinates where the target is located. The PM/O enters the coordinates into his global positioning system (GPS) and then uses either the *distance* or *go to* function to determine the distance to the target. This method is particularly useful during interdiction operations where the landings or crossing points being observed have been assigned waypoints in the PM/O's GPS.

RANGE-CARD METHOD

A range card contains a sketch with determined distances to fixed objects within the target area. This information may be obtained in advance using a map of the target area, or it may be gathered on site during the operation. Once a target has been identified, the PM/O determines were it is located on the range card and then identifies the approximate range to the target using the range rings. More is mentioned about range cards in Section 11.

MIL-SCALE RANGING

Mil-dot ranging is one of the most accurate methods of ranging. It uses the mil-scale reticle available in some riflescopes and binoculars. The "mil" in mil-dot stands for milliradian, which is a unit of angular measurement. One milliradian translates into 6283 parts of a circle or .0573 degrees.

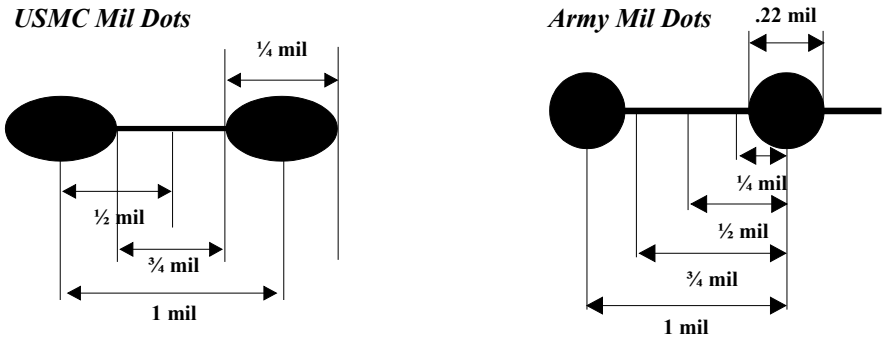


When looking through a mil-dot scope the shooter will see a set of crosshairs with a series of evenly spaced dots running along both crosshairs. These dots may be round or oval depending on which style of mil-dot reticle is being used. The U.S. Army round mil-dot reticle and the

USMC oval mil-dot reticle are the two primary mil-scale reticles used in tactical precision rifle applications.

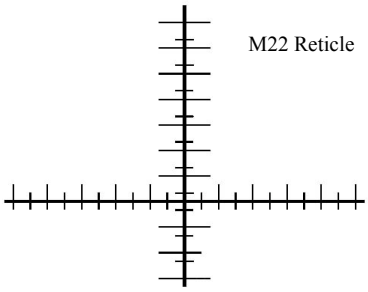
The USMC oval dots are ¼-mil wide and the distance between the inner edges of one dot to the next is ¾-mil. From the center of one dot to the center of the next is one mil. The distance between the heavy posts is 10 mils, and the distance between a heavy post and the intersecting crosshair is 5 mils.

The Army round dots are commonly referred to as ¼-mil dots, but in reality are ¾-MOA dots (.22 mils). The distance from the center of one dot to the center of the next is one mil; however, the ¼ and ¾-mil locations are quite different from the USMC reticle.



The measurement difference between the Army and USMC reticles is a result of two different interpretations of a milliradian. As mentioned previously, one mil is the equivalent of 1/6283th of a circle. While the USMC reticle uses a true mil translation, the Army reticle is based on the Artillery method of rounding 6400 mils to a circle.

Mil-scale binoculars such as the M19 or M22 have a different type of reticle. The reticle contains two intersecting bars with 10 tick marks on each bar. Each tick mark is five mils long and the distance between the tick marks is 10 mils. The reticle may have smaller tick marks in between the larger tick marks for more precise measurements.



At a distance of 1,000 yards one mil is equal to one yard. At a distance of 1,000 meters one mil is equal to one meter. In other words, one mil is 1/1,000th of the distance to the target. This means that at 100 yards one mil is equal to 3.6 inches, and at 10 yards one mil is equal to .36 inches.

To determine range using a mil-scale reticle, the PM/O must know the size of the target he is ranging. Once the size of the target is known the PM/O can compare the target in relation to the mil-scale reticle and then determine the range by using one of the following mil relation formulas:

$$\frac{\text{Size of Target (Meters)} \times 1{,}000}{\text{Mils}} = \text{Distance (Meters)}$$

$$\frac{\text{Size of Target (Yards)} \times 1{,}000}{\text{Mils}} = \text{Distance (Yards)}$$

$$\frac{\text{Size of Target (Inches)} \times 25.4}{\text{Mils}} = \text{Distance (Meters)}$$

$$\frac{\text{Size of Target (Inches)} \times 27.77}{\text{Mils}} = \text{Distance (Yards)}$$

For example, if the PM/O knows that the average size of a human head is 9 inches from the bottom of the chin to the top of the forehead and it measures two mils on his mil-scale, then he can determine that the target is about 125 yards away.

$$\frac{9 \times 27.77}{2} = 124.96$$

When milling an object, it is important that the surface of the object be perpendicular to the shooter. If the object is sitting at an angle then its apparent size will be reduced, resulting in a mil reading that is less than it should be.

If the shooter is at an angle above or below the object being milled he should try to mil a horizontal measurement. If the shooter must mil a vertical measurement from an angle above or below the object, he must first determine the adjusted size of the object before completing the mil relation formula.

Object Size **x** Cosine = Adjusted Size

SLOPE	5º	10º	15º	20º	25º	30º	35º	40º	45º
COSINE	.99	.98	.96	.94	.91	.87	.82	.77	.70

SLOPE	50º	55º	60º	65º	70º	75º	80º	85º	90º
COSINE	.64	.57	.50	.42	.34	.26	.17	.09	.00

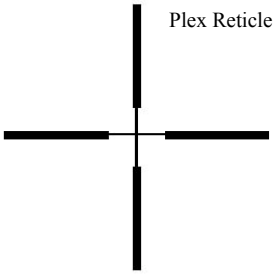
Example: The actual object size is 80 inches and the slope angle is 35º. The cosine factor for 35º is .82. Using the above formula it is determined that the adjusted size of the object is 65.6 inches (80 x .82 = 65.6). The mil relation formula is then completed using 65.6 inches for the object size.

When ranging with a mil-dot scope the PM/O must be cognizant of whether he is using a fixed-power or variable-power scope. Military sniper scopes are usually fixed 10x scopes. Law enforcement sniper scopes are typically variable-power to allow for short-range and low-light engagements. When the power setting on a variable-power scope is changed, the image in the scope gets bigger or smaller but the size of the reticle does not change; therefore, to use a variable-power scope for ranging, the scope must be set to its highest magnification setting.

The PM/O should record the sizes of commonly encountered objects in his data book. This information can then be referenced during mil-scale ranging. See Appendix B for ranging measurements.

PLEX RETICLE RANGING

A *plex* reticle design consists of two intersecting wires, much like the mil-dot reticle. Each wire has a thick portion that tapers to a very thin line in the middle. The purpose of this design is to draw the shooter's eye to the center of the scope picture. Even though the plex reticle does not have mil-dots, it can still be used for estimating ranges in a fashion similar to the mil-scale reticle.



In order to use a plex reticle for range estimation the PM/O must know the MOA measurements of the reticle for the scope he is using. This information can be obtained from the manufacturer and is usually printed on the literature that comes with the scope. Once this information is known, the PM/O can compare an object of known size in relation to the reticle and can determine the range by using the following formula:

$$\frac{\text{Size (Inches)} \times 104.72}{\text{MOA}} = \text{Distance (Yards)}$$

For example, on the Leupold Vari-X III the thick portion of the wire is 8/10 MOA wide and the narrow wire is 10 MOA long (five MOA to center). If a human head (9 inches) stretched the entire length of the narrow wire, then it can be determined that the target is just under 100 yards away.

$$\frac{9 \times 104.72}{10} = 94.24$$

Plex reticle ranging works best at shorter distances, due to the fact that it measures relatively large angles. As with mil-dot scopes, variable-power plex scopes must be set to their highest power for accurate range estimation.

RANGE FINDERS

Optical Range Finder

An optical range finder uses a type of triangulation to determine the range to a target. It consists of two lenses, each sending an image to a single eyepiece. These images overlap and the user adjusts the device until the two images line up to make a clear picture. The dial measures the difference in angle between the line-of-sight of each lens and the distance at which the two lines converge. The portable versions of these devices are not very accurate and should not be used for PM/O operations.

Laser Range Finder

A laser range finder is similar to an optical range finder in that it uses a form of triangulation to measure distance. It uses a transmitter to send out a light beam to the target. When the beam hits the target it is reflected back to the receptor, creating a triangle between the transmitter, receptor, and the target. The lens focuses the incoming light onto a position detector, which determines the angle at which the light is being reflected. This angle determines the distance to the target.

A laser range finder is the most accurate type of range finder; however, there are inherent problems with this type of device. Laser range finders work better at night than during the day, since ambient light sometimes contains light in the same wavelength as the transmitted light. A dull target may not reflect enough light and a bright background may reflect more light than the target. Either one of these may give a false reading. The objective is to aim the device so that as much light as possible is reflected off the target and as little as possible is reflected from the background.

BALLISTICS

INTRODUCTION

Ballistics is defined as the study of the movements and forces involved in the propulsion of objects through the air, or the study of projectile dynamics. To the PM/O, ballistics specifically deals with the firing, flight, and effect of ammunition. A thorough knowledge of ballistics combined with the execution of proper marksmanship fundamentals will ensure accurate shot placement, thereby reducing the risk to non-hostiles and team members, and ensuring a successful mission.

The tables and formulas given in this section should be used only as guidelines. Every rifle performs differently; therefore, the knowledge gained through experience and the ballistics data recorded in a well-kept PM/O data book are invaluable.

TERMINOLIGY

Ballistic Coefficient

A ballistic coefficient is a number that relates to the effect of air drag on the bullet's flight and can be used to predict a bullet's trajectory under different under different conditions through the use of drag tables.

Bullet Drift

Bullet drift refers to the horizontal distance the bullet travels from the line of departure to the point of impact.

Bullet Drop

Bullet drop refers to the vertical distance the bullet travels from the line of departure to the point of impact.

Bullet Nutation

Bullet nutation is a variation of the spinning bullet's rotation axis.

Bullet Path

Bullet path is the distance the bullet travels above the line of sight

Flight Time

Flight time is the amount of time the bullet takes to reach the target after leaving the muzzle of the rifle.

Line of Departure

The line of departure is the imaginary line defined by the bore of the rifle. The path the bullet would take without the effects of gravity. Line of departure is also known as the line of bore.

Line of Sight

Line of sight refers to an imaginary straight line that runs from the shooter's eye, through the aiming device, to point of aim.

Maximum Ordinate

Maximum ordinate refers to maximum height above the line of sight a bullet travels on its way to the target. The bullet reaches maximum ordinate somewhat past the midrange point, which is why it is also referred to as midrange trajectory.

Minute of Angle

A minute of angle is a unit of angular measurement equal to $1/60^{th}$ of a degree (1.0472 inches at 100 yards).

Muzzle Velocity

The muzzle velocity is the speed of the bullet as it leaves the muzzle of the weapon. Muzzle velocity is measured in feet per second (fps). Temperature, humidity, type of ammunition, and lot number can cause muzzle velocity to vary. In actuality, muzzle velocity determines the range of the weapon.

Retained Velocity

Retained velocity refers to the speed of the bullet at the time it reaches the target, since velocity is reduced due to drag.

Trajectory

The path of the bullet as it travels to the target is called trajectory.

TYPES OF BALLISTICS

Internal Ballistics

Internal ballistics is the study of the internal workings of a weapon and its ammunition. The time frame begins when the weapon is fired and ends when the bullet exits the muzzle.

External Ballistics

External ballistics refers to the study of the flight of the bullet from the time it leaves the muzzle until it reaches the target. Velocity, trajectory, and accuracy are the most important factors of external ballistics.

Terminal Ballistics

Terminal ballistics is the study of what happens to the bullet after it hits the target. Bullet penetration, expansion, and weight retention are all factors of terminal ballistics.

INTERNAL BALLISTICS

Internal ballistics plays a crucial role in rifle accuracy. The different characteristics of a particular rifle directly affect chamber pressure, which has a direct correlation with bullet velocity, and bullet nutation.

Headspace

A rifle's headspace is the distance from the bolt face to the surface in the chamber that stops the bullet casing's forward movement. With bottle-necked cases, the measuring point is centered on the shoulder of the case and is known as the datum line. A tight headspace prevents case over expansion resulting in greater chamber pressure. Greater chamber pressure results in greater projectile velocity.

Freebore

Freebore is the distance a bullet has to jump between the chamber and the bore before its bearing surface contacts the lands of the rifling. The purpose of freebore is to delay resistance and prolong pressure buildup. Too much freebore causes bullet instability which has an adverse affect on accuracy.

Barrel Erosion

Barrel erosion, also referred to as barrel wear, is the gradual eroding of the rifling lands directly in front of the chamber throat. This eroding occurs because the metal surface is burned away by the intensely concentrated powder flame. Barrel erosion results in a loss of chamber pressure.

Barrel Inside-Diameter

Another weapon characteristic that affects chamber pressure is the inside diameter of the barrel. The tighter the inside diameter of the barrel is the greater the chamber pressure will be when the weapon is fired. The inside diameter of a barrel will wear with extended use, resulting in a loss of pressure.

Chamber Concentricity

Chamber concentricity simply refers to how straight the chamber is. A straight and precise chamber will result in less bullet nutation.

Harmonics

In accordance with Sir Isaac Newton's *Third Law of Motion*, when a rifle is fired there is an amount of energy pushing the rifle backward (known as recoil) equal and opposite to the amount of energy pushing the bullet forward. The energy for both of these actions is generated by the exploding and expanding gasses resulting from the fired casing. Some of that energy is lost through the vibrating of the rifle barrel.

A rifle barrel acts very much like a tuning fork when a round is fired through it. All of the forces present—the bullet being pushed forward, the weapon being forced backward, even the spin of the bullet—cause the barrel to vibrate. These barrel vibrations cannot be eliminated, so it is ideal to allow the barrel to vibrate naturally and consistently by having is *free floated.* This means that the barrel is not allowed to touch anything, including the stock, from the receiver forward.

EXTERNAL BALLISTICS

As mentioned previously, the study of external ballistics is mainly focused on accuracy, velocity, and trajectory. These three areas are intertwined; therefore, it is impossible to affect one without affecting the others. Discussed here are factors that influence the flight of a bullet and ways to compensate for the deviation from line of sight and weapon zero.

Gravity

Gravity is an ever-present force of nature that affects the bullet by pulling it downward as soon as it leaves the muzzle of the weapon. The PM/O must compensate for gravity by making elevation adjustments or by using hold-off techniques.

Bullet Efficiency

The efficiency of a bullet is known as the *ballistic coefficient*. The bullet coefficient is a mathematical figure used to predict the bullet performance in flight. The standard bullet used for the G_1 drag model has a ballistic coefficient of 1.00; therefore, the closer to 1.00 the bullet's coefficient is, the more efficiently the bullet will fly through the air.

There are two recognized atmospheres that ballistic coefficient data is based on: **Standard Metro** and **ICAO** (International Civil Aviation Organization). The Standard Metro is based on sea level, with a barometric pressure level of 29.53 inches Hg, a temperature of 59°, and a humidity level of 78%. The ICAO is also based on sea level, with a barometric pressure level of 29.92 inches Hg, a temperature of 59°, and a humidity level of 0%. Most ballistic data is based on Standard Metro.

Air Density

The density of the air depends on its temperature, pressure, and how much water vapor is in the air. The denser the air is, the slower an object will move through it, since the object has to push aside more or heavier air molecules. This air resistance is referred to as *drag*. The PM/O must have a thorough understanding of air density and how it affects the flight of a bullet.

Barometric Pressure

As air pressure increases, the ballistic coefficient decreases, resulting in less velocity. For altitudes up to about 5,000 feet, one inch of barometric pressure is equivalent to 1,000 feet (0.1 for every 100 feet) of altitude. This means that barometric pressure changes with elevation up to 5,000 feet at a rate of 1 inch Hg for every 1,000 feet.

Altitude

Air pressure decreases as altitude increases, resulting in lower air density. For example, air pressure decreases from around 1,000 millibars at sea level, to 500 millibars at about 18,000 feet. At 100,000 feet the air pressure is only about 10 millibars. Due to the fact that there is less drag at higher altitudes, the bullet is more efficient and will have a higher point of impact. Of all the atmospheric conditions affecting air density, altitude has the greatest influence.

Relative Altitude

When determining the affects of altitude on trajectory, the shooter must factor in the influence of barometric pressure. A bullet is not affected by the actual elevation, but by what is called *density altitude*, or the *relative altitude*. The relative altitude factors in the barometric pressure to determine the altitude equivalency of the current atmospheric conditions. Relative altitude can be figured using the following formula:

AE + (29.53 – Hg **x** 1,000) = Relative Altitude

AE = Actual Elevation
Hg = Current Barometric Pressure

Example: At an altitude of 4,500 the reported barometric pressure is 30.53 inches Hg. The PM/O subtracts 30.53 from 29.53 (Standard Metro), which equals -1. He then multiplies -1 by 1,000, which equals -1,000. This means that he would subtract 1,000 feet from the actual altitude of 4,500 to get the relative altitude of 3,500 feet. This is the figure the PM/O would use to determine altitude correction.

An alternative to using the formula above would be to purchase a pocket altimeter. Once properly calibrated, the altimeter will show the relative altitude.

Temperature

Temperature affects both the ammunition and the density of the air. When ammunition sits in direct sunlight the burn rate its powder increases. The result of the faster burn rate is greater muzzle velocity and a higher point of impact.

The most influential factor of temperature is the affect it has on the density of the air. Air density increases as the temperature decreases, and decreases as the temperature increases. The most accurate way of determining exactly how much temperature variation will impact the round is to refer to past experience as recorded in a PM/O data book.

Humidity

Humidity varies with altitude and temperature. Contrary to popular opinion, humid air is lighter and therefore less dense than dry air at the same temperature and pressure. This is because water vapor is a gas and has a light molecular weight. When water vapor enters the atmosphere it replaces some of the heavier nitrogen or oxygen molecules with the lighter water molecules. The reason the air may seem thicker to a person is that he is consuming less oxygen with each breath.

The military and police sniper community has generally accepted that an increase in humidity causes the bullet to drop. This theory is based on the misnomer that humid air is heavier and denser. As previously mentioned, the opposite is true. In actuality, fluctuations in the humidity level will change the air density and the ballistic coefficient, but the amount is at most about 1%. Humidity has such a small affect that for all practical purposes it can be ignored.

Wind

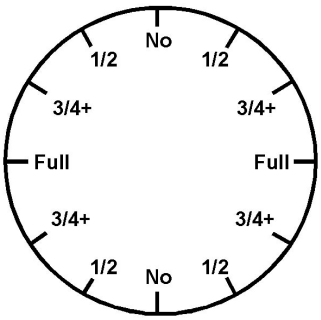
Wind is definitely the biggest problem for the PM/O. The affects of wind on a bullet increase with range. The longer flight time combined with the loss of velocity allows the wind to have a greater affect on the bullet as the distance increases, resulting in a loss of stability.

Wind Value

Wind value is based on the direction of the wind and determines how much influence the wind will have on the bullet. Wind direction can be determined by observing indicators such as smoke, trees, grass, rain, mirage, flags, and the sense of feel.

The best method for classifying wind value is the *clock method*. With the clock method, wind is assigned values based on the clock position from which it is blowing. Full-value means that the force of the wind will have a full affect on the bullet. Half-value and quarter-value mean the wind will move the bullet only half or a quarter as much as a full-value wind. No-value means that the wind will have little or no affect on the flight of the bullet.

Wind Value Clock



To classify the wind using the clock method, the PM/O imagines himself as being in the center of a clock with the target at the 12 o'clock position. A wind coming from the 3 or 9 o'clock position is considered a full-value wind. Winds coming from the 1, 5, 7, and 11 o'clock positions are considered half-value winds. Winds coming from the 2, 4, 8, and 10 o'clock positions are considered three-quarter-value winds. A no-value wind is a wind that comes from the 6 or 12 o'clock position.

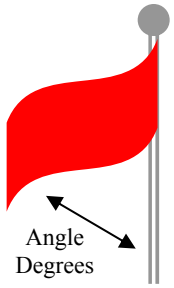
Wind Velocity

Before the PM/O can adjust his sighting system to compensate for the wind, he must determine the direction and velocity of the wind. There are several useful methods for estimating wind velocity and direction.

Range Flag Method

The range flag method is so called because of the red flag that is used on military ranges to signify a "hot" range. This method can be used with any visible flag, given that the flag is a heavy cotton fabric. Judging wind using a lighter, nylon fabric flag will skewer the formula.

To estimate velocity, the PM/O must determine the angle in degrees between the flag and the pole. This number is then divided by the constant number 4. The result is the approximate wind velocity in miles per hour.



$$\frac{\text{ANGLE}^\circ}{4} = \text{MPH}$$

Example: A shooter observes a range flag blowing at about a 60° angle from the pole. He then divides 60 by the constant 4 and determines that the approximate wind speed is 15 mph.

Observation Method

Another technique that is similar to the range flag method is the observation method. The PM/O holds some grass or other light material at shoulder level and then drops it. He then points directly at the spot where it landed, thus his arm becomes the flag and his body the pole. He then determines the angle in degrees between his arm and body and divides by the constant 4, resulting in the approximate wind velocity in miles per hour.

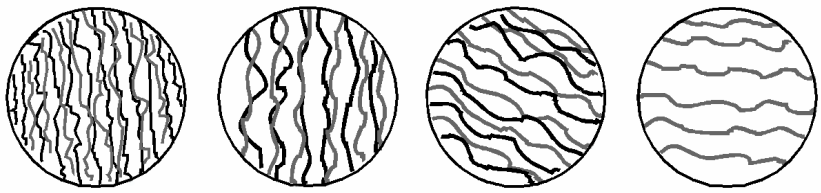
Face/Debris Method

Experience is a very important factor when estimating wind velocity. Observing how wind affects the environment will help in determining wind velocity. Winds less than 3 mph can barely be felt on the face. With 3-5 mph winds, a very light breeze can be felt on the face. With 5-10 mph winds, tree leaves are in constant motion, light ground debris is moving about, and small limbs are swaying on trees. With 10-15 mph winds, small trees begin to sway.

Reading Mirage

Mirage is the reflection of heat through layers of air at different temperatures. If there is a difference in ground and air temperatures, the PM/O will be able to see a mirage through his optics. Proper reading of the mirage enables the PM/O to estimate wind velocity (up to about 12 mph) and direction with a great deal of accuracy.

The wind nearest to midrange has the greatest affect on the bullet, so the PM/O should try to determine velocity at that point. This can be accomplished by focusing the scope on an object midrange, then placing the scope back onto target without readjusting the focus. The PM/O can also focus on the target, and then back the focus off ¼-turn counterclockwise. Doing this will make the target appear fuzzy, but the mirage will be clear.



Boiling Mirage **3-5 MPH** **5-8 MPH** **8-12 MPH**

As observed through optics, the mirage will appear to move with the same velocity as the wind, except when the wind is blowing at the 12 or 6 o'clock position. This is called a *boiling mirage*. A boiling mirage gives the appearance of moving straight upward with no lateral movement.

On a very hot or humid day, mirage can obscure or distort the target, causing the round to impact off target. Generally, if there is no wind and a boiling mirage is totally obscuring the target, the round will tend to hit high. This is because the mirage causes the target to appear higher than it actually is.

A boiling mirage may also be seen when the wind is constantly changing directions. Unless there is a no-value wind, the PM/O must wait for the boil to disappear before determining wind direction.

Converting Wind Velocity

Riflescopes have windage and elevation adjustments that are graduated in minutes of angle (MOA) or fractions thereof. These adjustments are made to compensate between the line of sight and the point of impact. When these two meet, the weapon has been zeroed.

A minute of angle is defined as 1/60th of one degree. This equals about 1 inch (1.0472 inches) for every 100 meters. For example, 1 MOA equals 2 inches at 200 meters and 5 inches at 500 meters.

Once the wind direction and velocity in miles per hour have been determined, the PM/O must then determine the MOA correction using one of the following methods:

Basic Wind Formula

The basic wind formula is used by U.S. military snipers and is taught at most sniper schools and precision rifle courses. The MOA correction is determined by multiplying the range to the target in hundredths by the wind velocity in miles-per-hour and then dividing by a constant number. The *constant* is a number that is assigned to the specific round being fired and varies with range.

$$\frac{\text{RANGE}/100 \times \text{VELOCITY (mph)}}{\text{CONSTANT}} = \text{MOA correction}$$

See Appendix A for Constants

The resulting MOA correction is for a full-value wind. To determine the actual MOA correction, this number is multiplied by the wind value percentage.

10-MPH Wind Deflection

To use the 10-mph wind deflection method, the PM/O must know how much a 10-mph crosswind will deflect his round at the given range. The PM/O can then extrapolate adjustments based on the given wind speed and wind value.

Example: The distance to a target is 250 yards and the wind velocity is 5 mph. A 10-mph wind would deflect a 168gr. Sierra MatchKing BTHP with a muzzle velocity of 2600 fps about 2 MOA. It can therefore be determined that a 5-mph wind (½ of 10) will deflect the bullet about 1 MOA.

The 10-mph wind deflection is based on a full-value crosswind; therefore, the actual correction will depend on the wind value for the given situation.

Slope Angles

The PM/O may find himself having to engage targets at a higher or lower elevation. Shooting from tall buildings or a high observation points are very likely scenarios for a PM/O. The PM/O may also have to shoot from a lower position to a higher position, such as when engaging a target in a second story window from ground level. Gravity always affects the flight of a bullet the same way, regardless of whether the PM/O is shooting at an upward or a downward angle. When shooting at a slope angle, the bullet will always strike the target high. How high the bullet strikes is determined by the range and the degree of angle to the target. The amount of elevation change applied to the rifle sighting system for angle firing is referred to as *slope dope*.

Since 100 yards is the ideal range to ensure precise hits, slope angles only begin to cause problems at 45°. Shallower angles can produce an effect, but at 100 yards their affects on the impact of the bullet are fairly insignificant. At ranges beyond 100 yards the affects of slope angles are much more significant.

For example, at 100 yards a 45° slope angle will cause a 308 cal. round to strike about ¾ MOA (¾ inch) high. Given the precise shooting required for most law enforcement situations, this much deviation from the line of sight coupled with any other shooter/weapon error or compensation problem can easily cause the shooter to miss. At 200 yards, a 30° angle will result in almost the same amount of deviation (¾ MOA) as a 45° angle at 100 yards. When considering that a ¾ MOA error at 200 yards will cause the round to strike about 1½ inches high, the importance of correctly compensating for slope angle cannot be understated.

When shooting at slope angles, the shooter must determine the angle by which the shot deviates from horizontal and either reduce the estimated range by determining the *actual horizontal range*, or reduce the amount of elevation correction by referencing an accurate drop table.

As mentioned previously, the slope angle affect is the same whether shooting at an upward or downward angle. In either case, the actual horizontal distance will be less than the estimated line-of-sight range; therefore, the amount of bullet drop will also be less.

Cosine Method

The cosine method is a field expedient "quick fix" method used for determining slope angle correction. While it is not completely mathematically correct, this method works fine at medium ranges and at

relatively shallow angles. Caution should be used when using this method if extreme precision is required.

With the cosine method, the corrected horizontal distance is calculated by multiplying the straight-line distance to the target by the cosine factor for the given slope angle. The PM/O then zeros his weapon for the corrected horizontal distance.

Range **x** Cosine = CHD

SLOPE	5º	10º	15º	20º	25º	30º	35º	40º	45º
COSINE	.99	.98	.96	.94	.91	.87	.82	.77	.70

SLOPE	50º	55º	60º	65º	70º	75º	80º	85º	90º
COSINE	.64	.57	.50	.42	.34	.26	.17	.09	.00

Example: The estimated range to a target is 500 yards and the slope angle is 35º. The cosine factor for 35º is .82. Using the cosine slope formula it can be determined that the corrected horizontal distance is 410 yards (500 x .82 = 410). The Marksman would adjust his weapon to compensate for drop at 410 yards.

Drop Table Method

The drop table method is a simplified version of the method advocated by the Sierra Bullet Company in their Reloading Manuals. The drop table method is much more involved and requires good ballistic data. It is more accurate than the cosine method; however, it can only be used when the PM/O has available an accurate ballistic table for his particular round.

To use the drop table method, the PM/O first adjusts his sighting system to the correct zero for the straight-line distance to the target. He must then reference his drop table to find the amount of bullet drop, in minutes of angle, from the line of departure. The amount of drop is then multiplied by the sine factor for the slope angle to get the MOA down correction. This correction is then applied to the sighting system to correct for the slope angle.

Bullet Drop (MOA) **x** Sine = MOA Down Correction

SLOPE	5º	10º	15º	20º	25º	30º	35º	40º	45º
SINE	.01	.02	.04	.06	.09	.13	.18	.23	.30

SLOPE	50º	55º	60º	65º	70º	75º	80º	85º	90º
SINE	.36	.43	.50	.58	.66	.74	.83	.91	.00

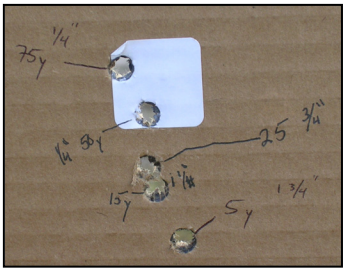
Example: The estimated range to a target is 500 yards and the slope angle is 35º. The amount of bullet drop for a 168gr. Sierra MatchKing BTHP at 500 yards is about 16¼ MOA. The sine factor for 35º is .18. Using the drop table formula it can be determined that the down correction for a 500-yard zero would be 3 MOA (16.25 x .18 = 2.93).

NOTE: While bullet drop is determined by the actual horizontal distance, wind correction is determined by the straight-line distance.

Sight Mechanics

Mechanical Offset

Mechanical offset refers to the distance between the line of sight and the line of bore. The higher the sighting system is set on the weapon, the greater the mechanical offset will be. When a weapon is fired at close range, the bullet will strike low because the bore line is below the line of sight. The picture displayed here illustrates the point of impact at 5, 15, 25, 50, and 75 yards for a Remington 40X with a sight height of 1.7 inches and zeroed at 100 yards.



Scope Cant

When a scope is mounted on a rifle it almost always runs parallel to the bore. An angle is created within the optics to adjust for the elevation needed to zero the rifle. The elevation correction within the optic points the line of sight downward, which in turn points the bore axis upward.

Cant error is generated when the barrel axis rotates out of the vertical plane and around the line of sight axis. It is a result of gravitational effects and barrel rotation. The trajectory of the bullet when the rifle is canted does not achieve the same height as when the rifle is held vertically. Since

the canted shot never reaches the full elevation of a vertical shot, it will drop below the vertical shot impact point. The elevation angle that is built into the optic acts as a windage error and directs the bullet's trajectory laterally off course in the direction of the cant.

Cant error can also be generated through an improperly mounted scope. A scope mounted and zeroed with a 5º cant when raised 9 MOA in elevation would generate a horizontal error of approximately ¼-MOA. This is again the result of the elevation adjustment being skewered due to the rotation of the optical system.

Scope Shadow

Scope shadow occurs when the shooter does not obtain proper eye alignment behind the scope. Instead of getting a clear reticle centered inside a uniform circle, a shadow will be present in the opposite direction of the eye misalignment. Firing the weapon when scope shadow is present will result in the round striking off the intended point of impact in the direction opposite the shadow.

TERMINAL BALLISTICS

The goal of the PM/O when firing on a suspect is to cause as close to *instant incapacitation* as possible. Anything less may risk the life of a hostage or other law enforcement personnel. In order to ensure instant incapacitation, the PM/O must have a good understanding of terminal ballistics.

Components of Projectile Wounding

Wounding is caused by the force exerted by a bullet to displace and damaged tissue in the form of penetration, cavitation, and fragmentation as the elastic limits of the tissue are exceeded by the stresses imparted from this force.

Penetration

Penetration is simply the depth the bullet passes through tissue. Penetration is affected by bullet shape, bullet construction, and impact velocity. Bullet construction determines whether the stress of impact will allow the bullet to penetrate the target. The shape of the bullet will determine whether it becomes unstable at impact, thus limiting

penetration. Impact velocity determines the resistance to penetration encountered by the bullet upon impacting the target.

Cavitation

Cavitation is caused by mechanical crushing and hydrodynamic pressure. Mechanical crushing occurs in the path of penetration and is caused by either an un-deformed bullet nose or an expanded bullet "mushroom." Hydrodynamic pressure causes damage from the pressure induced radial velocity extending from the point of the bullet to the outer edges of the bullet.

Permanent Cavity

Permanent cavity refers to the tissue that is destroyed by the projectile.

Temporary Cavity

Temporary cavity refers to the expansion of tissue. The tissue surrounding the permanent cavity will stretch as a result of the hydrodynamic force, and then rebound up to a certain point.

Fragmentation

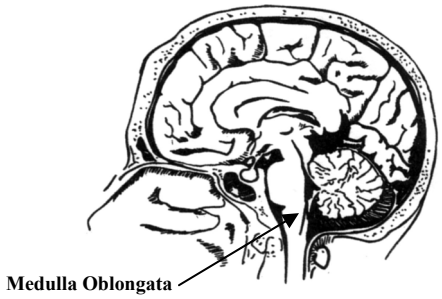
Fragmentation is the term used to describe pieces of the projectile, bone fragments, or other materials that separate and form their own wound channels.

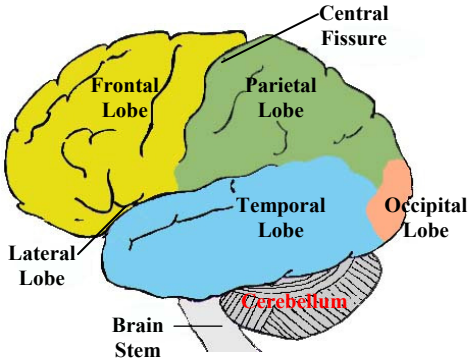
Primary Strike Points

The most important factor in wound lethality is bullet placement. The immediate cessation of life without any chance of reflex action is called ***flaccid paralysis***. The goal of flaccid paralysis is to collapse the central nervous system and thus prevent any reflex movement. Flaccid paralysis is best accomplished by striking a primary strike point.

Medulla Oblongata

The medulla oblongata is the lower portion of the brain stem that connects the upper spinal column to the midbrain. It is located where the upper spinal column enters the skull. The medulla oblongata is responsible for relaying signals between the brain and the spinal cord. A bullet strike to this area has the highest probability of flaccid paralysis because it controls all involuntary vital functions and rhythms.

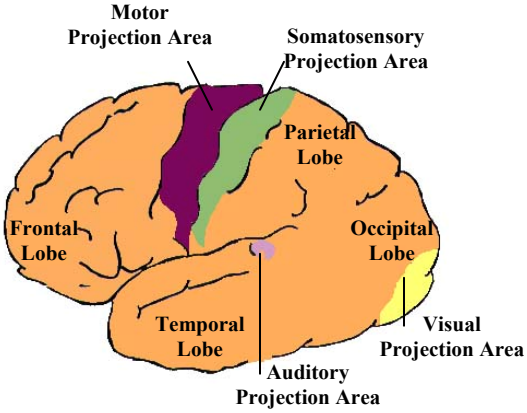




The aiming point for the medulla oblongata is centered on the bridge of the nose directly between the eyes.

Neural Motor Strip

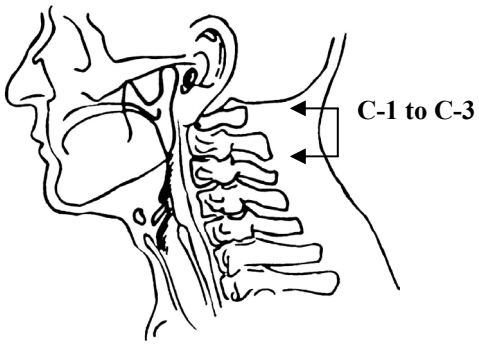
The neural motor strip or motor cortex is the last place in the brain where action planes are processed before the signal leaves the brain and is transmitted out to the body so that effectors will be stimulated.



The aiming point for the neural motor strip is located on the side of the head, from the top of the head to the top of the ear, centered on the ear, approximately 1-2 inches wide.

Upper Spinal Column

The upper spinal column, specifically vertebrae C-1 through C-3, is another primary target that will result in flaccid paralysis if struck with a bullet. This is the region where the brain stem and the spinal cord meet. It is located where the base of the skull meets the uppermost part of the neck.



The aiming point for the upper spinal column is roughly between and slightly below the ears if viewed from the rear, and above the mouth and cleft pallet if viewed from the front.

Secondary Strike Points

Other than hits to the central nervous system, the only reliable cause of rapid death (not necessarily flaccid paralysis) is through hemorrhaging produced by cutting through major blood-bearing organs or major blood vessels. The location and dimension of the cavity produced by the bullet will determine the rate of hemorrhaging and in turn the rapidity of the onset of death. Secondary targets are used when the PM/O cannot engage one of the primary strike points. Factors such as distance to the target, target movement, or target obstruction may result in the inability of the PM/O to engage a primary strike point.

Heart

When damage is done directly to the heart, circulatory functions may be arrested which will lead to unconsciousness within a few seconds.

Middle to Lower Spine

A strike to the middle or lower spine may not be immediately fatal. Instant incapacitation below the area where the spinal cord was severed may result from a strike to this area.

Points of Last Resort

Points of last resort should be used only in extreme emergencies when no other shot exists and the shot must be taken immediately or at long distance when precise shot placement is not possible.

Chest/Torso

The lethality of a shot to the chest/torso area depends on the loss of bile and bile exchange between inner organs. Effectiveness depends on exactly where the round strikes and what organs, tissue, and/or bone is damaged.

Lungs

The brain can store oxygen for up to 15 seconds; therefore, a strike to the lungs may not affect the intent or mobility of the suspect.

When engaging other than a primary strike point, the PM/O must weigh certain factors. Strikes to secondary strike points may cause an involuntary flinch or squeeze resulting in a discharged firearm. Strikes to other areas may allow the suspect to continue his action for several seconds or even minutes before unconsciousness or death occurs. Will a shot that does not result in instant incapacitation pose more danger to hostages, victims, and/or officers than if the shot was not taken?

SIGHTING SYSTEMS

INTRODUCTION

The Special Operations PM/O must be able to maintain and operate a variety of different weapon systems with a variety of sighting systems. This section will explain the operation and maintenance of some of the most popular sighting systems used in tactical operations.

RELATED TERMS

Field of View

Field of view refers the side-to-side measurement of the circular viewing field of the scope. It is defined by the width in feet or meters of the area visible at 100 yards or meters. A wide field of view makes it easier to spot threats and track moving targets. The higher the magnification of the scope is the narrower the field of view will be.

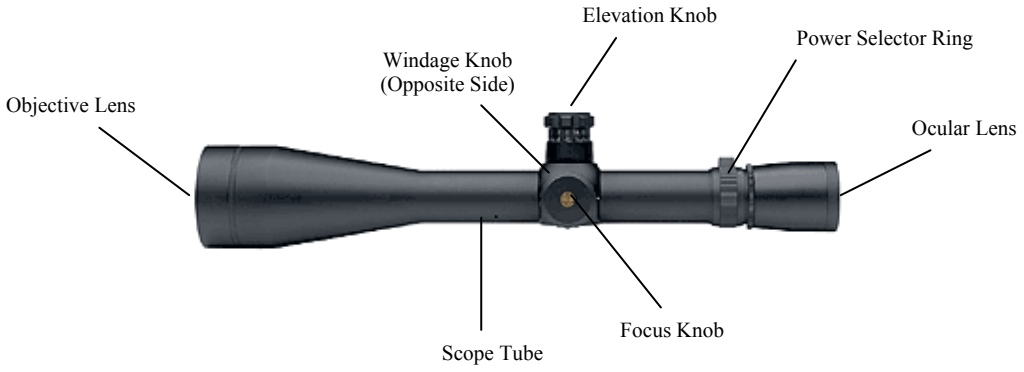
Parallax

Parallax is a condition that occurs when the image of the target is not focused precisely on the reticle plane. The result is an apparent movement between the reticle and the target when the shooter moves his head or, in extreme cases, as an out-of-focus image. The affects of parallax can be avoided by ensuring that the eye is well centered behind the scope.

Subtension

Subtension refers to the dimension covered by a portion of a reticle at a specific range. For example, if the heavy post of a duplex reticle covers two inches at 100 yards, then the reticle *subtends* two inches at 100 yards.

TELESCOPIC SIGHTS



Sight Function

Scope Tube

The scope tube is the main outer body of the scope and is made of steel or a lightweight alloy such as aluminum. It houses much of the scopes optical lenses as well as the reticle adjusting system.

Objective Lens

The objective lens is the lens that is located at the muzzle end of the scope and is primarily responsible for transmitting light. Objective lenses typically range between 20 to 60 millimeters.

NOTE: With a 3x9x40 scope, the "40" describes the objective lens diameter in millimeters.

Ocular Lens

The ocular lens is the lens closest to the eye and is smaller in diameter than the objective lens. The shooter can adjust the ocular lens to bring the reticle into focus.

Scope Lenses

Scope lenses are mounted internally and are coated with a chemical compound such as magnesium fluoride. This coating is approximately one 1,000,000th of an inch thick and is very delicate. The purpose of this

coating is to reduce the amount of light lost through reflection. A scope may have anywhere between six to eight scope lenses.

Elevation Knob

The elevation knob is located on the top of the scope and is used to make vertical adjustments. Turning the knob in the indicated direction will move the point of impact in that direction. Elevation knobs are set to move the impact of a round anywhere from ¼ to 1 MOA for each "click." This information can be obtained from the manufacturer.

NOTE: A scope with a positive adjustment system is desirable because it provides precise and repeatable adjustments.

Windage Knob

The windage knob is located on the right side of the scope and is used to make horizontal adjustments. Turning the knob in the indicated direction will move the point of impact in that direction. Most windage knobs are set to move the impact of a round ¼ or ½ MOA for each "click." This information can be obtained from the manufacturer.

NOTE: A scope with a positive adjustment system is desirable because it provides precise and repeatable adjustments.

Focus Knob

The focus knob is located on the left side of the scope and is used to focus the target image to the same focal plane as the reticle.

Power Selector Ring

The power selector ring is found on variable powered scopes and is located towards the rear of the scope and forward of the ocular lens. It will usually have magnification numbers around it to aid in adjustment.

Reticle

The reticle is the aiming point inside the scope and is commonly referred to as the crosshair. It appears in the shape of a crosshair, dot, triangle, or other distinct shape, and is superimposed on the image seen through the

objective lens. The advantage of a reticle is that it combines the functions of the front and rear sights into one image.

Sight Maintenance

Lens Care

The lenses of the scope are covered with magnesium fluoride to reduce light reflection and light scattering. Great care should be taken to avoid scratching the lens and removing this coating.

A lens brush should be used to remove dust from the lenses. The lenses should be cleaned with alcohol, glass cleaner, or pure water on a cotton swab or lens paper. The glass surface should never be cleaned with a dry cloth or paper towel and under no circumstances should a harsh cleanser such as acetone or DS2 be used on scope lenses. Lens covers should be used to protect the lenses when not in use.

Knobs, Rings, & Seals

All adjustment knobs, rings, and seals have a permanent lubrication and should not be lubricated. Dust covers should be kept on all adjustment knobs except when making sighting adjustments. Dirt and dust can be removed from knobs and rings by using a soft brush. Knobs or dials should never be forced.

Under no circumstances should the screw in the power selector ring be loosened. Loosening this ring may result in the loss of internal nitrogen. This nitrogen is what makes the scope fog free.

Preventive Maintenance

Lenses should be kept free from oil and grease and wipe off all moisture, dirt, and fingerprints as soon as possible. Lenses should never be touched with bare hands. Exposing scopes to direct sunlight for extended periods of time should be avoided and lens covers should be replaced when not in use.

M16A2/M4 IRON SIGHTS

Sight Function

Front Sight

The front sight post is used to make elevation adjustments when zeroing the weapon. Adjustments are made by depressing the detent and rotating the sight post clockwise to raise the impact or counterclockwise to lower the impact. Each graduation (notch) moves the point of impact 1.875 MOA on the M4 and 1.25 MOA on the M16A2.

RANGE	M4 (1.875 MOA)	M16A2 (1.25 MOA)
25 Meters	1.2 cm (.5”)	0.9 cm (3/8”)
100 Meters	4.8 cm (1 7/8”)	3.5 cm (1 3/8”)
200 Meters	9.6 cm (3.75”)	7 cm (2.75”)

Rear Sight Apertures

The large sight aperture is used when quick target acquisition is required, when engaging targets at close range (0-200 meters), and when engaging moving targets. The large aperture is only used when the elevation knob is set at the 300-meter setting (300 mark is aligned with the index mark on the left side of the receiver).

The small sight aperture is used when engaging targets at long distances, when zeroing the weapon, and when a more exact sight picture is necessary for precision shooting. The small aperture can be used in conjunction with the elevation knob for ranges from 300 meters to 600 meters (M4) or 800 meters (M16A2).

Elevation Knob

The elevation knob is located beneath the rear sight apertures and is used to make vertical adjustments. Each graduation (notch) of the elevation knob moves the point of impact 1.875 MOA for the M4 and 1 MOA for the M16A2.

The elevation knob is marked 6/3 on the M4 and 8/3 on M16A2. This marking indicates that in the lowest setting the rear sight is adjusted for 300 meters and in the highest setting the sight is adjusted for 600 meters

(M4) or 800 meters (M16A2). The other number increments represent meters to the hundredth power.

There is also a small "z" two clicks past the 6/3 or 8/3 setting. This setting is used when zeroing the weapon at 25 meters. Once the weapon has been zeroed at 25 meters, the elevation knob should be placed on the 300-meter setting.

Windage Knob

The windage knob is located on the right side of the rear sight assembly and is used to make horizontal adjustments. The windage knob has an "R" with an arrow pointing in a clockwise direction. Turning the knob clockwise will move the point of impact to the right. To move the point of impact to the left, the knob must be turned counterclockwise. Each graduation (notch) moves the point of impact .75 MOA on the M4 and .5 MOA on the M16A2.

RANGE	M4 (1.875 MOA)	M16A2 (1.25 MOA)
25 Meters	.5 cm (3/16")	0.3 cm (1/8")
100 Meters	1.9 cm (.75")	1.25 cm (.5")
200 Meters	4.8 cm (1.5")	2.5 cm (1")

Sight Maintenance

All sight components should be inspected periodically for bent or damaged parts and rust or corrosion. Moving parts should be inspected for proper operation. The sight should be cleaned with a brush and a dry rag and lubricated with CLP. Important areas that need to be lubricated are the windage knob and detent spring hole, the elevation knob detent spring hole, the windage screw, and the elevation screw.

M203 LEAF SIGHT

Sight Function

The M203 leaf sight assembly is attached to the top of the handguard of the M16/M4. The leaf sight assembly consists of the sight, its base and mount, an elevation adjustment screw, and a windage adjustment screw. Elevation and windage scales are marked on the mount. The folding, adjustable, open ladder design of the sight permits rapid firing without sight manipulation. The front

sight post of the M16/M4 rifle serves as the front aiming post for the M203 leaf sight.

Sight Base

Two mounting screws permanently attach the sight base to the rifle handguard. The base protects the sight from damage when the sight is not being used or is in the down position.

Sight Mount & Sight

The sight mount is attached to the sight base. It is used to raise or lower the sight. Though the range is not marked on the sight in meters, the sight is graduated in 50-meter increments from 50 to 200 meters. These increments are marked with a "1" at 100 meters and a "2" at 200 meters.

Elevation Adjustment Screw

The elevation adjustment screw attaches the sight to the sight mount. When the screw is loosened, the sight can be moved up and down to make minor adjustments in elevation during the zeroing procedure. Raising the sight increases the range, lowering the sight decreases the range.

Elevation Scale

The elevation scale consists of five equally spaced lines on each side of the zero line. Moving the sight one increment moves the impact of the projectile 10 meters in elevation at a range of 200 meters.

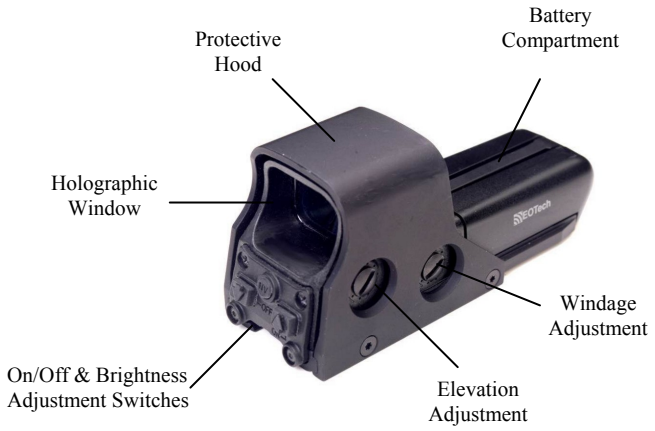
Windage Scale

Minor windage adjustments can be made during the zeroing procedure by turning the knob on the left end of the windage screw. The scale has a zero line in its center and two lines spaced equally on each side of the zero line. Moving the knob on the windage scale one increment moves the impact of the projectile 1.5 meters at a range of 200 meters.

Sight Maintenance

The leaf sight should be inspected periodically for bent or damaged parts and rust or corrosion. All moving parts should be inspected for proper operation. The sight should be cleaned with a brush and a dry rag and lubricated with CLP.

EOTECH HOLOGRAPHIC DIFFRACTION SIGHT



Sight Function

Protective Hood

EOTech HDS models 511, 512, 551, and 552 are equipped with a protective hood. This hood is preassembled at the factory and is non-removable. The hood lock screws should never be tampered with. If the hood requires maintenance, the sight should be sent to the manufacturer.

Battery Compartment

The battery compartment is located behind the reticle window. It is opened by lifting the locking cam lever and sliding the battery compartment away from the sight housing. The labels on the bottom of the battery compartment show the correct battery orientation. After replacing the batteries, the sight should be turned on to verify proper installation.

Electronic Push-Button Switches

The EOTech HDS is equipped with push-button switches located at the rear of the sight. Depressing the UP or DOWN arrow push-button switches will turn the sight on. If the UP arrow is used to turn the sight on it will be set at the eight-hour shutdown mode. If the DOWN arrow is used to turn the sight on it will be set at the four-hour shutdown mode.

The HDS automatically performs a battery check every time it is turned on. If the batteries have less than 20 percent life left, the sight will turn on with the reticle image blinking on and off for five seconds. If the remaining battery life is more than 20 percent, the sight will turn on with a steady reticle pattern. The battery condition can be checked any time by turning the sight off and back on.

The HDS is turned off by depressing both the UP and DOWN arrows simultaneously.

The brightness intensity of the holographic reticle pattern can be adjusted by depressing the UP and DOWN arrow switches. Depressing and releasing either switch will move the brightness level one step up or down from the previous setting. Depressing and holding either switch will change the brightness level up or down continuously. There are 20 brightness settings. When the sight is turned on, the brightness intensity level is automatically set to Level 12.

EOTech HDS models 551 and 552 are compatible with generation II, III, III+, and IV night vision devices. These models have a push-button switch labeled "NV" centered and offset from the UP and DOWN arrow buttons. Depressing the NV button will turn the sight on in night vision mode. The sight will automatically turn on at Level 4 and will automatically shut off eight hours after the last push-button control is used.

The HDS can be switched between normal and night vision modes by depressing the NV button. When switching between modes, the sight will remember the last brightness setting.

Elevation Adjustment Screw

The elevation screw is located on the right-hand side of the sight and is used to make vertical adjustments. Each graduation (click) of the elevation screw moves the point of impact ½ MOA. One full rotation of the elevation screw will move the point of impact 10 MOA. The elevation screw has the word "DOWN" with an arrow pointing in a clockwise direction. Turning the screw clockwise will lower the point of impact. To raise the point of impact, the screw must be turned counterclockwise.

Windage Adjustment Screw

The windage screw is located on the right-hand side of the sight and is used to make horizontal adjustments. Each graduation (click) of the windage screw moves the point of impact ½ MOA. One full rotation of the elevation screw will move the point of impact 10 MOA. The windage screw has the word "RIGHT" with an arrow pointing in a clockwise direction. Turning the screw clockwise will move the point of impact to the right. To move the point of impact to the left, the screw must be turned counterclockwise.

Reticle

The EOTech HDS uses laser light to illuminate a holographic reticle pattern embedded in the heads-up display window to form a virtual image of a reticle pattern. The shooter looks through the heads-up display window and sees a bright red image of a reticle pattern projected onto the target plane.

Sight Maintenance

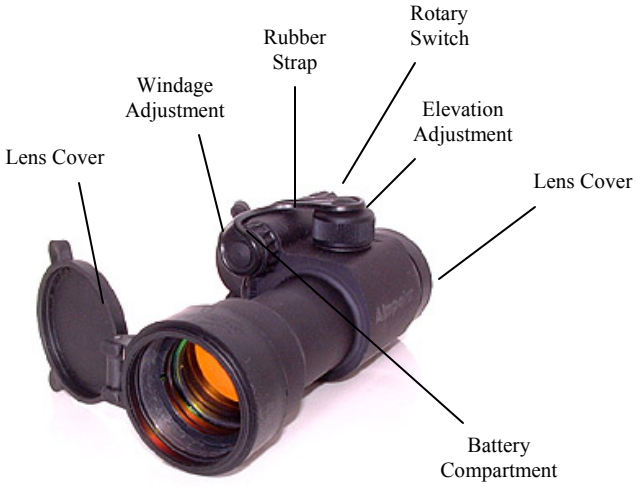
The optical system and window are coated with anti-reflection material. Loose dirt and dust on the glass surface should be blown off. Fingerprints and lubricants can be wiped off with lens tissue or a soft cotton cloth, moistened with lens cleaning fluid or camera glass cleaner. The glass surface should never be cleaned with a dry cloth or paper towel and under no circumstances should a harsh cleanser such as acetone or DS2 be used on scope lenses.

All moving parts of the sight are permanently lubricated and should not be lubricated. The optical cavity of the sight is purged, nitrogen filled, and sealed to achieve fog proof performance. The sight optical assembly should never be disassembled.

WARNING!

The illuminating beam can become accessible to the eye if the housing is broken. In case of breakage, the sight should be turned off and returned to the manufacturer for repair.

AIMPOINT COMPM2/M2-2X & COMPML2/ML2-2X



Sight Function

Battery Compartment

The battery compartment is located directly in front of the rotary switch. It is opened by turning the battery cap counterclockwise. The sight requires one 3-volt lithium battery type 2L76 or DL1/3N. When installing the battery it should be placed so that the positive (+) end faces toward the battery cap.

Rotary Switch

The rotary switch is positioned behind the battery compartment. It is used to adjust the intensity of the red dot reticle. Turning the switch clockwise will increase the brightness of the reticle. To adjust the reticle for night vision (CompM2 and CompM2-2X) or to turn it to the OFF position (CompML2 and CompML2-2X), the switch is turned counterclockwise.

Elevation Adjustment Screw

The elevation adjustment screw is located on the top of the sight and is used to make vertical adjustments. Each graduation (click) of the elevation adjustment screw moves the point of impact ½ MOA. Turning the adjustment screw counterclockwise will raise the point of impact. To lower the point of impact, the adjustment screw must be turned clockwise.

Windage Adjustment Screw

The windage adjustment screw is located on the right or left side of the sight (depending on how the sight is mounted) and is used to make horizontal adjustments. Each graduation (click) of the windage adjustment screw moves the point of impact ½ MOA. Turning the adjustment screw counterclockwise will move the point of impact to the right. To move the point of impact to the left, the adjustment screw must be turned clockwise.

Reticle

The Aimpoint CompM2 and CompM2-2X have a 4 MOA red dot reticle with four NVD settings and six daylight settings. The CompML2 and CompML2-2X have a 2 MOA reticle with nine daylight settings and an OFF setting.

Sight Maintenance

A lens brush should be used to remove dust from the lenses. The lenses should be cleaned with alcohol, glass cleaner, or pure water on a cotton swab or lens paper. The lens covers should be used to protect the lenses when not in use. When storing the sight for extended periods of time the battery should be removed and the lens caps should be opened to prevent condensation.

TRIJICON REFLEX

Sight Function

Fiber Optic System

The fiber optic system causes the reticle to glow brightly during the day so it can be clearly seen, and less brightly in low-light conditions to reduce contrast that can interfere with target acquisition. The fiber optic system can be covered to reduce the intensity of the reticle if necessary.

Elevation Adjuster

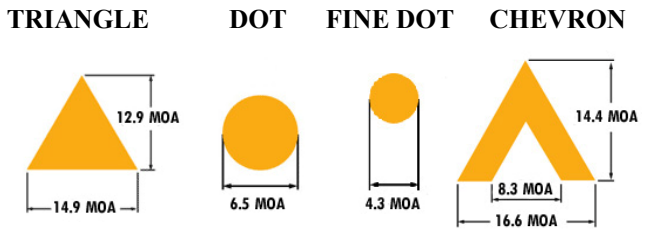
The elevation adjuster is located to the rear on top of the flat portion of the sight and is used to make vertical adjustments. Each graduation (click) of the elevation adjuster moves the point of impact 0.86 MOA. The elevation adjuster has the letter "U" with an arrow pointing in a clockwise direction. Turning the adjuster clockwise will raise the point of impact. To lower the point of impact, the adjuster must be turned counterclockwise.

Windage Adjuster

The windage adjuster is located on the right-hand side of the sight and is used to make horizontal adjustments. Each graduation (click) of the windage adjuster moves the point of impact 0.86 MOA. The windage adjuster has the letter "R" with an arrow pointing in a clockwise direction. Turning the adjuster clockwise will move the point of impact to the right. To move the point of impact to the left, the adjuster must be turned counterclockwise.

Reticle

The Reflex uses a fiber optic system and a tritium lamp to illuminate the reticle. The Reflex is aimed by centering the dot (dot reticle) or aligning the tip of the triangle or chevron (triangle and chevron reticles) on the desired point of impact.



Sight Maintenance

The Reflex requires very little maintenance. If the lenses become dirty, the unit may be washed using fresh water and a clean cloth. The lenses should be completely washed before wiping them with the cloth to avoid scratching. Fogged lenses can be wiped with a clean cloth.

WARNING!

The Reflex contains a radioactive material for nighttime illumination that is safe for normal exposure, but become 10,000 times more hazardous when burned. For this reason, great care should be taken to avoid flame in the presence of a Reflex scope with broken or leaking tritium lamp.

If the tritium lamp in a Reflex is broken or is suspected of being broken, the unit should be placed in a plastic bag and the manufacturer should be contacted for handling and replacement instructions.

TRIJICON COMPACT ACOG 2x20 BAC, 1.5x24 BAC, 3x24 BAC, & 1.5x16 BAC

Sight Function

Fiber Optic System

The fiber optic system causes the reticle to glow brightly during the day so it can be clearly seen, and less brightly in low-light conditions to reduce contrast that can interfere with target acquisition. The fiber optic system can be covered to reduce the intensity of reticle if necessary.

Elevation Adjuster

The elevation adjuster is located on the top of the sight and is used to make vertical adjustments. Each graduation (click) of the elevation adjuster moves the point of impact ½ MOA on the 2x20, 1.5x24, and 3x24, and 1/3 MOA on the 1.5x16. The elevation adjuster has the letter "U" with an arrow pointing in a clockwise direction. Turning the adjuster clockwise will raise the point of impact. To lower the point of impact, the adjuster must be turned counterclockwise.

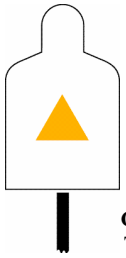
Windage Adjuster

The windage adjuster is located on the right-hand side of the sight and is used to make horizontal adjustments. Each graduation (click) of the windage adjuster moves the point of impact ½ MOA on the 2x20, 1.5x24, and 3x24, and 1/3 MOA on the 1.5x16. The windage adjuster has the letter "R" with an arrow pointing in a clockwise direction. Turning the adjuster clockwise will move the point of impact to the right. To move the point of impact to the left, the adjuster must be turned counterclockwise.

Reticle

The Compact ACOG BAC uses a fiber optic system and a tritium lamp to illuminate the reticle. Ranging capability has been built into the reticle pattern. The reticle is designed to be zeroed at 60 meters using the very top of the reticle as the point of aim. This will provide combat accuracy out to 250 meters.

The sight may be zeroed at 25 meters if a 60-meter range is not available. When zeroing at 25 meters the point of impact should be 3 inches below the point of aim.



Compact ACOG Triangle Reticle

Sight Maintenance

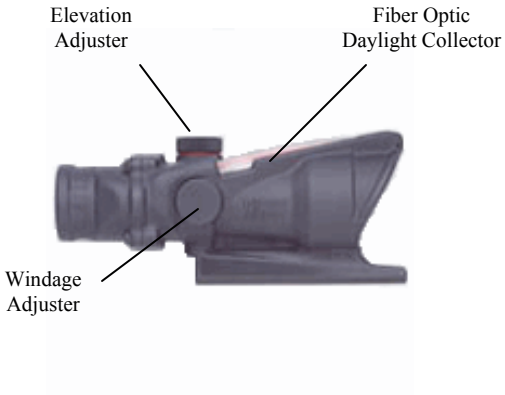
The Compact ACOG requires very little maintenance. If the lenses become dirty, the unit may be washed using fresh water and a clean cloth. The lenses should be completely washed before wiping them with the cloth to avoid scratching. Fogged lenses can be wiped with a clean cloth.

WARNING!

The Compact ACOG contains a radioactive material for nighttime illumination that is safe for normal exposure, but become 10,000 times more hazardous when burned. For this reason, great care should be taken to avoid flame in the presence of a Compact ACOG scope with broken or leaking tritium lamp.

If the tritium lamp in a Compact ACOG is broken or is suspected of being broken, the unit should be placed in a plastic bag and the manufacturer should be contacted for handling and replacement instructions.

TRIJICON ACOG 3.5x35 BAC, 4x32 BAC, & 5.5x50 BAC



Sight Function

Fiber Optic System

The fiber optic system causes the reticle to glow brightly during the day so it can be clearly seen, and less brightly in low-light conditions to reduce contrast that can interfere with target acquisition. The fiber optic system can be covered to reduce the intensity of the reticle if necessary.

Elevation Adjuster

The elevation adjuster is located on the top of the sight and is used to make vertical adjustments. Each graduation (click) of the elevation adjuster moves the point of impact ¼ MOA on the 3.5x35, 1/3 MOA on the 4x32, and 1/6 MOA on the 5.5x50. The elevation adjuster has the letter "U" with an arrow pointing in a clockwise direction. Turning the adjuster clockwise will raise the point of impact. To lower the point of impact, the adjuster must be turned counterclockwise.

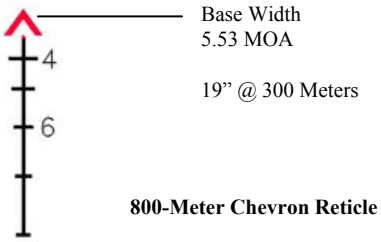
Windage Adjuster

The windage adjuster is located on the right-hand side of the sight and is used to make horizontal adjustments. Each graduation (click) of the windage adjuster moves the point of impact ¼ MOA on the 3.5x35, 1/3 MOA on the 4x32, and 1/6 MOA on the 5.5x50. The windage adjuster has the letter "R" with an arrow pointing in a clockwise direction. Turning the adjuster clockwise will move the point of impact to the right. To move the point of impact to the left, the adjuster must be turned counterclockwise.

Reticle

The ACOG BAC uses a fiber optic system and a tritium lamp to illuminate the reticle. Ranging capability has been built into the reticle pattern. The reticle is designed to be zeroed at 100 meters using the very top of the reticle as the point of aim.

Once the sight has been zeroed, targets at longer ranges can be engaged using different aiming points on the reticle pattern. To engage a target at 200 meters, the top of the donut hole (donut reticle) or the inside of the chevron (chevron reticle) is used as the aiming point. At 300 meters, the bottom of the donut hole (donut reticle) or the illuminated dot inside the chevron is used. At ranges of 400 meters and beyond, the bullet drop compensator below the illuminated reticle is used.



800-Meter Chevron Reticle

Sight Maintenance

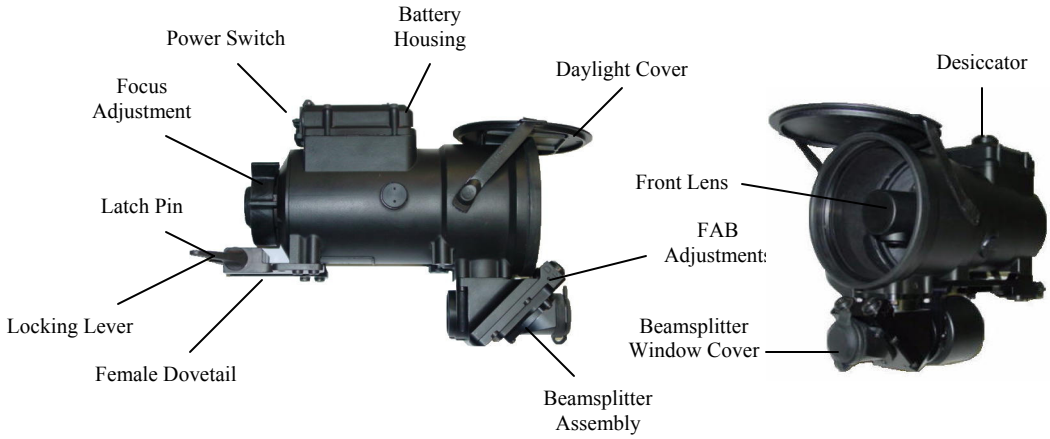
The ACOG requires very little maintenance. If the lenses become dirty, the unit may be washed using fresh water and a clean cloth. The lenses should be completely washed before wiping them with the cloth to avoid scratching. Fogged lenses can be wiped with a clean cloth.

WARNING!

The ACOG contains a radioactive material for nighttime illumination that is safe for normal exposure, but become 10,000 times more hazardous when burned. For this reason, great care should be taken to avoid flame in the presence of an ACOG scope with broken or leaking tritium lamp.

If the tritium lamp in an ACOG is broken or is suspected of being broken, the unit should be placed in a plastic bag and the manufacturer should be contacted for handling and replacement instructions.

SIMRAD KN203 & KN253 NIGHT WEAPONS SIGHTS



Sight Function

Battery Compartment

The battery compartment houses the two AA batteries needed to power the Simrad NWS and is located on top of the device near the power switch. The battery compartment is opened by turning the battery compartment lid screw and lifting the battery compartment lid. The correct battery orientation is indicated on the battery compartment housing.

Power Switch

The power switch is located on top of the NWS near the battery compartment. It controls the power to the image intensifier assembly and adjusts the system gain. Rotating the power switch clockwise will activate the image intensifier and will increase the gain as it continues rotate.

Focus Adjustment

The focus adjustment is the large knob located on the rear of the NWS. It adjusts the position of the Mangin mirror to achieve the sharpest image of the object being viewed. Focal adjustments are made by rotating the focus adjustment in either direction.

FAB Unit

The FAB unit is located above the beamsplitter and enables the NWS to be bore-sighted when it is installed or when it is moved from one weapon to another. The FAB adjustment screw marked with the "R↓" moves the point of impact horizontally, and the adjustment screw marked with the "D↓" moves the point of impact vertically. Each graduation (click) of the FAB adjustment screws move the point of impact approximately ½ MOA. The arrows indicate in which direction the screws need to be rotated to move the point of impact right or down as indicated.

When bore-sighting the NWS, the weapon should be fired during twilight at the same distance at that the day scope is zeroed using the Simrad NWS bore-sighting target. When the NWS is properly bore-sighted, the point of impact should be 3.75 inches below the point of aim for the KN203 and 2.75 inches below the point of aim for the KN253. The FAB adjustment screws should be used to move the point of impact into the proper strike zone located on the Simrad bore-sighting target.

Simrad Bore-Sighting Target

NOTE: The FAB unit is used for bore-sighting the NWS only and should never be used to make windage and elevation changes for distance shooting.

Daylight Cover

The daylight cover, when in place, allows for daylight testing and operation of the NWS and protects the objective lens from dirt and damage. The cover is held in place by a rubber strap and is held open by the daylight cover retaining lip. The daylight cover should be installed on the NWS prior to daylight use to prevent damage to the image intensifier tube.

Dovetail Assembly

The dovetail assembly consists of a male dovetail that mounts onto the day scope and a female dovetail located at the bottom of the NWS. The male dovetail is mounted onto the day scope by removing the top half of the forward scope mount and replacing it with the male dovetail. The top half of the mount is then mounted underneath the male dovetail alongside the forward mount.

Male Dovetail

The female dovetail is designed to align with the male dovetail for a high-tolerance connection. The NWS is mounted onto the day scope by aligning the female dovetail with the male dovetail, depressing the latch pin located on the female dovetail, sliding the NWS rearward until fully seated, releasing the latch pin, and then locking the locking lever.

Locking Lever

Located on the female dovetail at the bottom of the NWS, the locking lever securely locks the NWS to the day scope. The locking lever is unlocked when it is in the "up" position and locked when it is in the "down" position.

Latch Pin

The latch pin is positioned on the female dovetail behind the locking lever. The latch pin is used to prevent the NWS from dislodging from the day scope in the event that the locking lever is released.

Beamsplitter Assembly

The dichrotic beamsplitter below the FAB adjustment screws allows the operator to view directly through the day scope without removing the NWS. The beamsplitter window cover is used to block the direct light path to the day scope when the NWS is being used.

Stray Light Shield (KN203 Only)

The stray light shield located behind the beamsplitter assembly directs intensified light into the day scope and prevents foreign matter from accumulating in the space between the beamsplitter and the day scope.

Desiccator

The desiccator absorbs moisture from the atmosphere contained within the NWS to prevent fogging of the internal optical surfaces. The desiccator contains silica gel which is highly hygroscopic material. The humidity indicator can be viewed through the glass window of the desiccator located near the battery compartment housing. The indicator is blue when dry and becomes pink when the silica gel can no longer absorb moisture.

Sight Maintenance

Desiccator

The desiccator should be inspected periodically for blue or pink indication. If the desiccator is pink, the system should be returned to an authorized maintenance facility for replacement.

Optical Surfaces

A lens brush should be used to remove dust and dirt from the optical surfaces. If necessary, the optical surfaces can be cleaned using lens paper and either alcohol, isopropanol, a lens cleaning solution, or water. The optical surfaces should be dried thoroughly after cleaning.

Housing Exterior

The exterior of the NWS can be cleaned with a mild detergent and warm water. The system should be thoroughly dried prior to use.

WARNING!

The image intensifier assembly phosphor screen contains toxic materials. If any assembly becomes broken, extreme caution should be taken to avoid inhalation and mouth/open wound contact of the phosphor screen material. If this material comes in contact with the skin it should be washed off immediately with soap and water. **If any of the phosphor material is swallowed, force drink water, induce vomiting, and seek immediate medical care.**

ADVANCED SHOOTING TECHNIQUES & SPECIAL SITUATIONS

INTRODUCTION

The essence of the PM/O is his ability to apply, if needed, precision fire to a rapidly evolving life-threatening situation. There are several advanced shooting techniques that can increase the PM/O's effectiveness when properly applied. In addition, there are a number of special shooting situations that the PM/O may find himself having to address. Having a solid foundation of understanding of these situations will prepare the PM/O for mission success.

HOLD-OFF

Hold-off is defined as the shifting of the point of aim to achieve a desired point of impact. This technique is used when the PM/O does not have time to change his sight setting, such as when engaging multiple targets at varying ranges. The lack of a precise aiming point can make delivering shots with pinpoint accuracy very difficult.

Elevation

To compensate for elevation using hold-off, the PM/O aims either above or below the desired point of impact, depending on the range of the target and the range the sighting system is set for. For example, if the sight elevation has been adjusted to engage a target at 500 yards and a target appears at 600 yards, the PM/O would have to aim higher (hold-over) than the desired point of impact to compensate for bullet drop. If a target appears at 400 yards, the PM/O would have to aim lower (hold-under) than the desired point of impact to prevent the bullet from striking high.

To use hold-over or hold-under effectively, the PM/O must know the difference in bullet path between the zero range and the target range, and then compensate for that difference accordingly.

For example, if the bullet path for a 100-yard zero is -15.9 inches at 300 yards and -66.7 inches at 500 yards, then the difference in bullet path between 300 and 500 yards would be -50.8 inches. If the PM/O had his dope set for 300 yards and needed to take a shot at 500 yards, then he would hold-over 50.8 inches. On the

other hand, if the PM/O had his dope set for 500 yards and had to engage a target at 300 yards, then he would hold-under 50.8 inches.

To convert inches to mils: $\frac{\text{Inches} \div (\text{Range in Yards}/100)}{3.6} = \text{Mils}$

To convert MOA to mils: MOA **x** 0.296 = Mils

Windage

To compensate for windage using hold-off, the PM/O aims into the wind. The amount of hold-off the PM/O will use is dependent on the wind speed, the range to the target, and the wind direction. The PM/O should first determine the amount of wind correction needed using one of the methods mentioned in Section 4, and then convert MOA into either mils or inches.

To convert MOA to mils: MOA **x** 0.296 = Mils

To convert MOA to inches: MOA **x** (Range in Yards/100) **x** 1.0472 = Inches

MOVING TARGETS

Four Factors of Moving Targets

Speed

The faster a target is moving, the more distance it will cover during the bullet's flight, thereby requiring a greater lead.

2 mph – slow walk	6 mph – jog	15 mph – fast run/sprint
3 mph – normal walk	10 mph – run	20 mph – fast sprint
4 mph – fast walk		

Angle

A target moving perpendicular to the line of sight will cover a greater lateral distance than a target moving at an angle toward or away from the line of sight.

Range

The farther the target is from the shooter, the longer it will take the bullet to travel downrange and reach the target. Target lead must increase as range increases.

Wind

A target that is moving against the wind will require more lead than a target that is moving in the same direction as the wind.

Target Leads

Full Lead

A full lead is used when a target is moving perpendicular to the PM/O's line of sight. To determine the amount of lead necessary for engaging a moving target, the PM/O can use one of the following formulas:

Time of Flight (seconds) **x** Target Speed (fps) = Lead (feet)

Time of Flight (seconds) **x** Target Speed (fps) **x** 12 = Lead (inches)

The target speed can be converted from miles-per-hour (mph) to feet-per-second (fps) by multiplying by 1.4667. (MPH **x** 1.4667)

For example, a target is moving at a speed of 2 mph at a distance of 200 yards. The time-of-flight for a typical 168 grain .308 round at that distance is 0.24823 seconds. The following shows the steps taken to determine the target lead:

2 (mph) x 1.4667 = 2.9334 (fps)
0.24823 x 2.9334 = .728157882 (feet)
.728157882 x 12 = 8.737894584 (inches)
Lead = 8.75 inches

If the PM/O is using a scope with a mil-scale reticle, he can use the horizontal mil-dots to lead the target. The amount of lead in mils can be calculated by using the following formula:

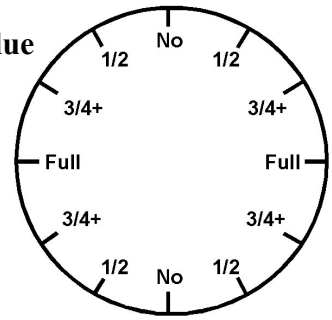
$$\frac{\text{Lead in Inches} \div (\text{Range in Yards}/100)}{3.6} = \text{Mil Lead}$$

Partial Lead

A partial lead is used when the target is moving at an oblique angle toward or away from the PM/O. The same mathematical theories that determine the amount of affect the wind has on a bullet at different angles are the same theories that determine how much lead a moving target requires at different angles.

To determine the amount of partial lead, the PM/O can use the *lead value clock* much like the wind value clock. The PM/O first determines the speed of the target then calculates the lead using the above formulas. The PM/O then uses the lead value clock to determine what percentage of a full lead to use.

Lead Value Clock



No Lead

If a moving target is moving straight toward or straight away from the line of sight, then no lead is necessary. The PM/O can simply align his sights at the desired point of aim and shoot. The speed of the target moving toward or away from the PM/O is not relevant.

Vertical Movement

A PM/O may find himself in a situation where he has to engage a moving target that has a vertical movement component. Since a human threat moves in three dimensions, the target may have a vertical movement component combined with a lateral movement component. Distance to the target, target speed, and slope angle are factors that will determine how much the PM/O must compensate for vertical movement.

The PM/O's position in relation to the target is the most important aspect of vertical target movement. If the PM/O is on the same plane as the target, then the target's vertical movement is not relative, although compensation may need to be

made for slope angle (See Section 4). Vertical movement becomes relative when the PM/O is shooting from a level position and the target is moving uphill or downhill on a slope.

To determine the amount of compensation necessary for the vertical movement component, the PM/O uses the same process mentioned above, but substitutes the angle of the slope for the oblique angle. The degree of the slope angle is referenced on the lead value clock to determine what percentage of a full lead should be used.

Example: A PM/O must engage a threat that is moving laterally from right to left at a speed of 4 mph at an oblique angle of 30°. The threat is also moving downhill on a 15° slope. The distance to the target is 200 yards. The following steps are taken to determine the amount of lead:

4 (mph) x 1.4667 = 5.8668 (fps)
0.24823 x 5.8668 = 1.456315764 (feet)
1.456315764 x 12 = 17.475789168
17.475789168 x .50 (*Lead Value*) = 8.737894584
Horizontal Lead = 8.75 inches

4 (mph) x 1.4667 = 5.8668 (fps)
0.24823 x 5.8668 = 1.456315764 (feet)
1.456315764 x 12 = 17.475789168
17.475789168 x .25 (*Lead Value*) = 4.368947292
Vertical Lead = 4.5 inches

The PM/O will need to aim approximately 8.75 inches to the left of the target and approximately 4.5 inches low.

Wind Factor

If the PM/O is holding for wind while leading a moving target, he must adjust his lead to compensate for the velocity and direction of the wind in contrast with the speed and direction of the target. This is done by calculating the normal amount of target lead and either adding or subtracting the determined wind holdoff.

Target moving into the wind: Target Lead + Wind Holdoff = Total Lead

Target moving with the wind: Target Lead - Wind Holdoff = Total Lead

Target Leading Methods

Trapping/Ambush Method

The trapping method is used when the threat is moving predictably and the PM/O can determine where the threat is going (i.e. to a doorway or vehicle). The PM/O aims his weapon ahead of the target, allowing for a proper lead, and holds his weapon steady. When the target arrives at the aim point, the PM/O fires and allows the target to move into the bullet. This method works well, especially at short distances (100 yards or less) when the slightest movement can cause the PM/O to loose the target from his field-of-view.

When using the trapping method, the PM/O should lead from the leading edge of the target. This allows for the time laps that occurs between the moment he acquires his sight picture and the instant he pulls the trigger.

Tracking Method

The tracking method requires the PM/O to establish a moving lead and to hold that lead in front of the target as the target moves. This technique is used when the PM/O does not have the option of choosing the timing of the shot, such as when firing on command or when engaging a moving hostage taker. When using the tracking method, the PM/O should lead from center mass of the target and should continue tracking through the trigger squeeze.

Track-Trap Method

This a combination of the tracking and trapping methods and requires the PM/O to aim and hold out in front of the target by just a few feet and let the target move into the sight picture. The shooter only holds steady for a few seconds at a time, until the shot is fired or the target no longer presents itself.

Short Range Leads

At ranges within 100 yards, an alternative leading method that works well is to use the leading edge of the target as the aim point and engage using one of the leading methods mentioned above. Because of the relatively short time of flight at 100 yards, the PM/O can use this technique to obtain effective hits on a target moving at any speed between one to four feet per second.

COUNTDOWNS & COMMAND FIRING

Command Fire

Command firing is usually used when multiple Marksmen must engage multiple threats simultaneously. Command firing is controlled with the commands "STAND BY. . . STAND BY. . . STAND BY. . .FIRE."

During simultaneous engagement there are some very delicate coordination issues that must be addressed. Each Marksman must advise when he is actively tracking his target and is ready to engage at any time by stating that he is "UP." If his target disappears or he is unable to engage for any reason, the Marksman must immediately announce that he is "DOWN." During this process, the controller command will be "STAND BY."

As soon as the controller recognizes that all of the Marksmen are "UP," he will give one last command of "STAND BY" and will then give the command "FIRE." Upon the "FIRE" command, all Marksmen will engage their targets simultaneously.

Countdowns

Countdowns are used to control the timing of a shot to either coordinate it with an assault or to synchronize the shots of two or more Marksmen. When performing a countdown, the controller will first verify that all elements are ready and will then announce "ALL UNITS ARE UP, I HAVE CONTROL." The countdown will then proceed with "5. . . 4. . . 3. . . 2. . . 1. . . EXECUTE, EXECUTE, EXECUTE." The Marksman or Marksmen will fire on the count of "*two*," and if an assault team is involved, they will breach the entry point on the count of "*one*."

SHOOTING AT INANIMATE OBJECTS

Suicide Attempts

During a suicide attempt when the subject has a deadly weapon and is an imminent threat to himself, the PM/O may be justified in shooting at the suspect's weapon. The PM/O must be able to prove that the suspect intended to end his own life *at that very second*, and that shooting at the suspect's weapon was the only option available to save the subject. Furthermore, the PM/O must be able to

articulate how the inherent risk of such action was an acceptable alternative to death.

Target Availability

When a suspect presents an imminent deadly threat to human life and the only target available is the suspect's weapon, the PM/O may be justified in shooting at the weapon that is being used to present that threat. The PM/O must be able to articulate that the only viable option in stopping the threat was to shoot the suspect's weapon, since the suspect presented no other alternative.

Glass Breakage

The PM/O may need to fire at glass in front of a threat in order to remove the glass to avoid round defection. This will usually be done as part of a synchronized shot. When using this tactic, the first PM/O fires a split second before the second PM/O to allow the second shot to proceed directly to the threat without glass interference.

SHOOTING THROUGH SOLID MEDIUM

Firing through solid medium can present several problems. How the flight of the bullet will be impacted cannot always be determined. The PM/O must consider whether firing through a medium is worth the risk of bullet deflection.

As a general rule, a PM/O should never shoot through anything he cannot see through. A deflected round could strike an innocent person, or may miss the threat and cause the incident to escalate. Shooting through opaque concealment, such as vegetation, should be avoided except in **extreme emergencies**. Doing so incurs an extremely high level of liability, since the target and what lies beyond the target cannot be positively identified.

Ricochet Factors

There are four major factors that affect bullet ricochet. Understanding these factors is important when shooting through medium, as well as when evaluating the backstop beyond the target.

Impact Surface

Hard and smooth surfaces are more likely to cause a bullet to ricochet than soft and rough surfaces.

Angle of Incidence

The lesser the angle at which a bullet impacts a surface (*angle of incidence*), the greater the chances are that the bullet will ricochet. A bullet that strikes a surface perpendicularly (90°) will have the least risk of ricochet.

Bullet Shape & Construction

Flat nosed and soft-tip bullets are less likely to ricochet than full-metal-jacketed bullets, due to the fact that they are more likely to fragment on impact.

Bullet Speed

The faster a bullet is traveling when it hits an object, the more likely it will deform or fragment. This results in depleted bullet energy, thereby decreasing the chances of bullet ricochet.

Glass Penetration

There are many possible scenarios where the PM/O may have to shoot through glass to stop a threat. Several factors must be considered when shooting through glass medium. The density and composition of the glass, the composition of the round being used, the distance of the shooter from the glass, the distance of the target from the glass, and the angle of the shooter from the glass are all important factors that must be considered before taking a shot at a target behind glass.

Types of Glass

There are several different types of glass that are used on the outer surfaces of buildings and automobiles. Each type has its own unique qualities, and each responds differently when impacted by a bullet. Knowing the characteristics of different types of glass is important when determining the risks involved with shooting through glass.

<u>Annealed Glass</u>

Annealed glass, or "ordinary" glass, is the weakest and most common type of glass. It is also the easiest type of glass to shoot through. A bullet passing through annealed glass will usually

leave a hole with a "spider web" fracture around it. Annealed glass may be found in low-income residential windows. It cannot be used for windows located within a door, within 18 inches of the floor, or within 12 inches of a doorframe due to current building codes.

Tempered Glass

Tempered glass goes through a special hardening process that makes it two to four times stronger than annealed glass. Fully-tempered glass is used in applications requiring increased strength and reduced likelihood of injury in the event of breakage. Tempered glass shatters into many small, relatively harmless fragments when broken. This phenomenon known as "dicing," dramatically reduces the likelihood of injury because no jagged edges or sharp shards are produced.

Fully-tempered glass can satisfy federal, state, and local building code safety requirements in applications such as doors, side lights, shower and bathtub enclosures, interior partitions, and storm doors; therefore, this type of glass is widely used in commercial and residential structures. The motor vehicle industry also uses tempered glass for side and rear windows in automobiles, trucks, and multi-purpose vehicles.

Laminated Glass

Laminated glass consists of two or more glass sheets with one or more interlayers of resin or plastic (PVB). When broken, the interlayer holds the glass fragments together and continues to provide resistance to penetration. Laminated glass is used where it is necessary to maintain the integrity of the whole sheet after breakage, usually due to safety or security concerns.

The most common use of laminated glass is in automobile windshields. Some transit buses use laminated glass for the side windows. Laminated glass is also used in many storefront windows to prevent smash-and-grab burglaries.

Dual-Glaze Glass

Dual-glaze glass consists of two layers of glass mounted inside a frame with a pocket of air trapped in between. This design is used to provide better insulation or sound proofing within a structure.

Due to its insulation value, dual-glaze glass is almost universally used for residential windows in cold-climate areas. It may also be used in extremely hot climates for the same reason. Residences located near freeways or busy streets may have dual-glaze windows to reduce the traffic noise.

Wire Glass

Wire glass is manufactured by sandwiching a steel wire mesh between two ribbons of semi-molten glass. The impact resistance of wire glass is similar to that of annealed glass except that the wire mesh helps retain the broken pieces when the glass is fractured. Wire glass is traditionally accepted in structures as low-cost fire glass.

Glass Thickness

When shooting through a glass barrier the PM/O should take into consideration not only the composition of the glass, but also the thickness of the glass. Glass thickness can range from 1/16" to 1¼" or greater depending on its application.

Ballistic Effects

There are two primary concerns when shooting through glass. The first is whether or not the bullet will strike its intended target, and the second is whether or not it will retain enough energy to penetrate the target after passing through the glass. When examining the possible outcome there are a number of terminal ballistic effects that should be considered.

Bullet Deflection

The amount of deflection a bullet exhibits will vary in direct proportion to the degree of stability it retains after striking the glass. If the bullet becomes deformed after striking the glass, its center of gravity and center of mass will be shifted so that they are

no longer located on the same axis. When this happens the bullet will loose rotational velocity and veer off course.

Bullet Destabilization

When a bullet is fired through a rifled barrel it is forced to rotate around its center of mass. Upon exiting the muzzle the bullet begins to rotate around its center of gravity. In a perfect bullet the center of mass and the center of gravity are the same; however, if the jacket is just .001 inch thicker on one side then more of the lead core will be located on the opposite side. Such imperfection will cause the center of gravity to be located off center towards the heavy side of the bullet.

While the axis around which the bullet rotates is shifting the bullet becomes unstable and will *yaw*, which means it will wobble around its axis. The bullet will stabilize once it begins rotating around its center of gravity. Stabilization can occur anywhere between 10 and 100 yards depending on the bullet design, the rate of twist in the rifling, and the amount of bullet imperfection.

When a bullet strikes a piece of glass before it has stabilized the possibility of the bullet deforming, loosing rotational velocity, tumbling, and missing the intended target becomes more likely.

Core/Jacket Separation

Upon striking glass, a typical hollow-point bullet will usually flatten back toward the base. The glass will slow down the jacket, while the heavy lead core carries its momentum and exits the jacket through the hollow opening. The soft lead is deformed and begins to destabilize. At this point the lead core's point of impact becomes unpredictable. The jacket will also continue through the glass with an even more unpredictable flight path. Both projectiles at this point may be lethal if enough energy has been retained.

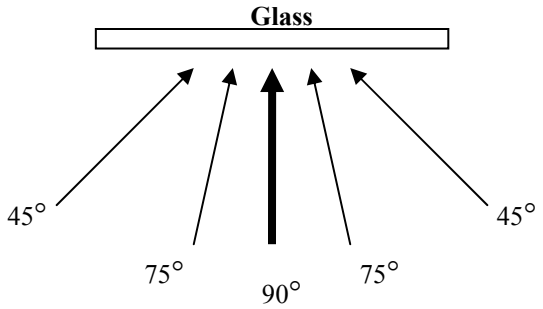
Spawling

When a bullet impacts a piece of glass, fragments of broken glass and any laminate are ejected in a path perpendicular to the glass plate. This phenomenon is referred to as *spawling*. These ejected fragments may be sharp and could cause severe injury to someone

on the opposite side of the glass, depending on his/her angle and distance from the glass.

Shooting Angles

When shooting through glass medium the PM/O should strive to position himself as close to perpendicular (90°) to the glass as possible. The PM/O should also position himself as close to the glass as possible to reduce the risk of deflection, but not so close that bullet destabilization becomes a factor.



The closer the threat is to the glass, the better the chances will be that the bullet will hit its intended target. A shot taken at 100 meters at an angle less than 75° requires the target to be no more than five feet from the glass.

The following table illustrates the maximum distance a threat can be from household window glass for a shot taken at 100 meters. A distance greater than that listed for the given angle may result in round deflection and a missed target.

Shots Taken at 100 Meters on Household Window Glass

ANGLE	MAX DISTANCE OF THREAT FROM GLASS
90° (Perpendicular)	8-10 Feet
75° or More	4-5 Feet
70°-60°	3-4 Feet
60°-50°	36 Inches or Less
45°	8-10 Inches

Results Will Vary With Environmental Conditions & Glass/Round Composition

When shooting through glass medium, slope angles have the same limiting affect as left and right angles. Slope angles should be limited to 75° or more. The PM/O must also compensate for slope angle as mentioned in Section 4.

USMC Glass Penetration Testing Results

The United States Marine Corps conducted a glass penetration test by shooting at an 8" x 9" pane of safety glass at 45º and 90º angles. Their test concluded the following:

1. The path of the test bullet core was not affected up to five feet beyond the initial point of impact regardless of the angle fired from.

2. When hit from an angle, glass fragments were always blown perpendicular to the glass plate.

3. The 173 grain test bullet's copper jacket fragmented upon impact. All of the bullet fragments followed an erratic path both in height and width. The main core (lead) began to tumble approximately two feet from the initial point of impact.

4. Due to the plastic lamination of the safety glass, large fragments of plastic were embedded in the target one foot from the point of impact. These fragments were large enough to cause severe wounds.

5. Glass fragments did not penetrate targets that were farther than one foot from the glass.

OBSERVATION & THREAT DETECTION

INTRODUCTION

Observation and information gathering is the most important function of the PM/O. To perform this function effectively, the PM/O must understand how his optics work and what they are best suited for. More importantly, the PM/O must know how and what to observe, how to record information thoroughly and accurately, and how to communicate information clearly and concisely.

PHYSIOLOGY OF VISION

The retina of the human eye contains two types of photoreceptors. These photoreceptors are called *cones* and *rods*. Cones provide the eye's color sensitivity and are responsible for all high resolution vision. They are less sensitive to light than the rods and adapt rapidly to changing light levels. Cones can be divided into red, green, and blue cones. The red and green cones are concentrated in the fovea centralis. The blue cones have the highest light sensitivity and are found mostly outside the fovea. This results in some distinction in the eye's blue perception. The visual perception of intensely blue objects is less distinct than the perception of objects of red and green.

Rods are more numerous and more sensitive than cones; however, they are not sensitive to color. Rods are responsible for scotopic (dark-adapted) vision. Optimum scotopic vision is obtained only after a considerable period of darkness (approximately 30 minutes or longer) because the rod adaptation process is much slower than that of the cones.

While visual acuity and visual resolution is much better with the cones, the rods are better motion sensors. Rods predominate in the peripheral vision; therefore, peripheral vision is more sensitive to light, enabling dimmer images to be seen in the peripheral vision. These images may disappear when looked at directly because the image is moved onto the cone-rich fovea region, which is less sensitive to light. Motion can also be detected better with peripheral vision.

The light response of rods peaks sharply in blue light and responds very little to red light. For this reason, red light can be used at night without spoiling dark-adapted vision.

OPTIC PERFORMANCE FACTORS

Objective Lens

The objective lens is the lens that is closest to the end of the telescope and is larger in diameter than the ocular lens, which is the lens closest to the eyepiece. The objective lens is normally expressed in millimeters and is usually between 20 to 60 millimeters for riflescopes. The size of the objective lens contributes immensely to the quality of the optics. A large objective lens gathers more light and provides a clearer resolution.

Exit Pupil

The exit pupil refers to the size of the shaft of light transmitted to the eye. The larger the exit pupil, the brighter the image will appear. The exit pupil is an important indicator of the optical system's low-light performance. The exit pupil can be seen by holding the eyepiece of the optical system approximately 12 inches from the eye. It is the bright circle of light in the center of the eyepiece. Exit pupil is expressed in millimeters and is normally derived by dividing the size of the objective lens by the magnification.

Twilight Factor

The twilight factor is an indication of how well an optical system will perform in poor light. The higher the twilight factor, the more clearly fine details can be discerned during early morning and twilight (limited visibility) operations. Twilight factor is calculated by taking the square root of the product of the magnification factor and the objective lens diameter.

For example, a 7-power optical system with a 50-millimeter objective lens (7x50) has a twilight factor of 18.7. The Leupold M3A riflescope found on the M-23 Sniper Weapon System has a 40-millimeter objective lens with a magnification power of 10; therefore, the M3A riflescope has a twilight factor of 20.

Magnification

Magnification is defined as the ratio of the size of an image to the size of an object. An optical system that has a magnification power of 10 will make an image appear 10 times larger than its actual size.

Optical systems allow the PM/O to view an object in greater detail by essentially pulling the object closer to the eye. In other words, an object viewed through a

20-power optical device at a distance of 100 meters will appear to be the same size at it would if it were viewed with the naked eye at a distance of 5 meters. This relative distance is determined by dividing the distance in meters by the magnification power. (100 meters/20 power = 5 meters)

One of the problems that can occur with high magnification is that shooter movement, mirage, and haze are transmitted through the optical system. Another problem is that the field of view decreases as magnification increases. A limited field of view can cause the PM/O to lose sight of moving targets or to miss other threats altogether.

During low-light operations, an optical system with high magnification can create a visibility problem for the PM/O. Variable powered optical systems can be used effectively in low light levels by reducing the magnification to draw more light through the telescope.

Field of View

Field of view refers the side-to-side measurement of the circular viewing field of an optical device. It is defined by the width in feet or meters of the area visible at 100 yards or meters. A wide field of view makes it easier to spot threats and track moving targets. As previously mentioned, the higher the magnification, the narrower the field of view.

TACTICAL OPTIC SYSTEMS

Binoculars

Binoculars are best suited for scanning large areas. This is due to the fact that binoculars have a lower magnification and therefore a wider field of view than a spotting scope for example. When choosing binoculars for tactical use, all performance factors should be considered. Compact binoculars are convenient and easy to carry, but do not perform well under low-light conditions due to the fact that they have poor light transmitting capability.

Spotting Scopes

A spotting scope has a large objective lens and high magnification; therefore, it has a narrow field of view. Spotting scopes are designed for focusing on specific areas, not for scanning unknown areas.

For example, a spotting scope with a field of view of 52 feet at 1,000 yards, which equates to 13.3 meters at 1,000 meters, would allow the PM/O to see 6.65 meters to either side of the subject. At 100 yards, this spotting scope would have a field of view of 5.5 feet, which means the PM/O would only be able to see 2.75 feet to either side of the subject.

A spotting scope being used for tactical operations should be rugged, rubber armored, and all weather. A scope with a 60mm objective lens has the ability to extend observation well into twilight.

Riflescopes

Telescopic sighting systems are discussed in detail in Section 5; however, as with all optical devices, the previously mentioned performance factors should be considered when selecting a riflescope.

Night Vision

Night vision devices can be used for area observation, team movement overwatch, and target identification. They can be used in conjunction with infrared chemlights, flashlights, and lasers. Infrared chemlights can be used to mark trails, targets, or team members. Infrared flashlights can be used to aid visibility during extreme darkness. Infrared lasers can be used for target identification or for additional illumination. These infrared devices should be used cautiously, since the threat may have access to night vision equipment as well.

Photographic Equipment

The PM/O may be tasked to use photographic equipment depending on the mission objectives. Photographic equipment is most likely to be used during intelligence gathering or pre-assault scouting missions. Photographs of suspects and buildings make the assault planning much easier for the entry team.

When taking photographs during scouting missions, there are several areas that should be covered. These areas include possible entry points, cover and terrain near the objective, alarms or animals in the target area or on the route to the objective, windows, fences, and lighting.

OBSERVATIONAL OBJECTIVES

Before deploying on a mission, the PM/O must know and understand the observational objectives of the mission. The observational objectives are what the mission commander believes to be criteria for a successful mission and should be discussed during the initial mission brief. It is then the PM/O team's responsibility to identify equipment needs and team capably.

Hasty

Due to the time allowed or the severity of the situation, a hasty mission is limited to finding, identifying, and eliminating threats. Virtually all missions begin with a hasty deployment because of the need to identify suspects and threats to the team and to provide accurate fire if needed. As the situation develops and time allows, the mission may develop into an overwatch mission.

Overwatch

An overwatch includes all of the aspects of a hasty mission, but also includes scanning the inner perimeter for obstacles and hazards to the assault team. The PM/O team will look for any signs that the suspect has been alerted to the presence of the SRT, and will determine if he poses a threat to the SRT or other officers. The PM/O team will cover the assault team's movement to and from the target area, eliminating any threats that cannot be engaged by the assault team.

Scout

A scout mission requires the PM/O team to determine the assault team's best avenue of approach to the target area. The team must also locate and identify any special hazards, booby traps, clandestine laboratories, etc. within the target area. Once these duties are completed, the PM/O team may then set up an operating position and observe the area for a period of time in order to gather intelligence.

PROACTIVE INFORMATION GATHERING

The PM/O team should gather information using a systematic method. Using a systematic searching method ensures that the PM/O team will not miss critical pieces of information.

Hasty Search

A hasty search is a quick check of the immediate area to aid in team security. This is done to identify any immediate threats to the PM/O team or the assault team.

When conducting a hasty check, the PM/O should check obvious locations where a threat may be located such as doors, windows, and vehicles. A point-to-point check should be used rather than a panoramic sweep of the area. Once all obvious threat areas have been checked, a range card with reference points and range estimations can be completed.

Deliberate Search

Once the main threat or suspect has been located, the Marksman acquires the target and the Observer conducts a deliberate search of the area. If the main threat is not located with the hasty search, then the Marksman and the Observer begin a deliberate search.

When conducting a deliberate search, one team member begins scanning from one side to the other, looking approximately 50 meters (or as KOCOA dictates) in front of his position. He continues scanning back and forth in 50 meter overlapping increments. The second team member searches using a grid system. The area is divided into small grids and is searched one grid at a time. These grids can be drawn on the range card and labeled with letters or numbers.

During a deliberate search, any small threat areas such as vehicles, doorways, corners, etc. should be micro searched. Any areas were a threat may appear such as entry points for vehicles or buildings should be ranged and recorded with any necessary dope changes. Detailed notes should be made concerning any threats, dead space where targets cannot be engaged, or anything else about the area of operation that may seem important.

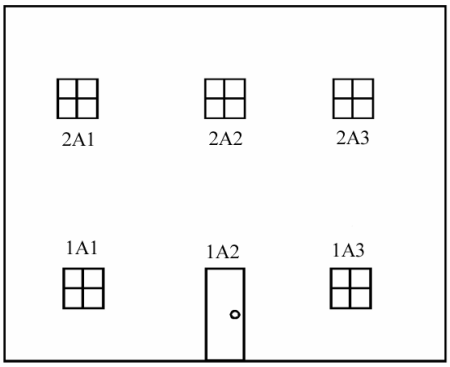
BUILDING SECTORIZATION

Sectorization is a method of breaking a building down into smaller pieces to allow the PM/O and the SRT to acquire targets and relay information effectively.

Detailed Sectorization

The sides of the structure are assigned letters of the alphabet beginning with the letter "A" and working clockwise around the building. The side with the most identifiable landmark is designated as the Alpha side.

Each level of the structure is given a numerical designator starting at the bottom floor and working upward. When the level and side designators are combined the result is an alphanumeric reference. For example, the bottom level of the front side would be 1A, and the second level of the front side would be 2A.

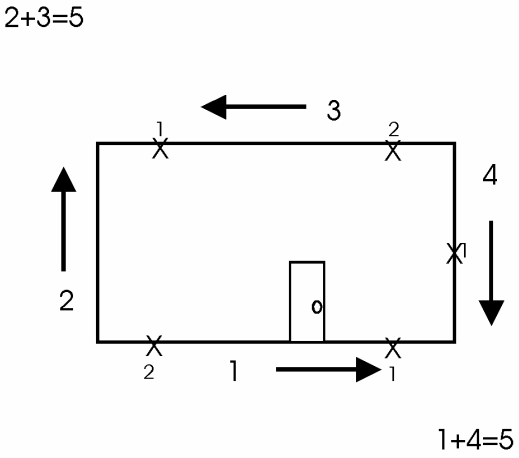


The openings around the structure (doors, windows, etc.) are given numerical designators. The openings are numbered from right to left according to the level they are located on. The opening designator comes after the alphabetic side indicator in the alphanumeric reference. The first opening on the first floor of front side of the structure would be 1A1.

Front 5–Back 5

The F5-B5 method can be used in worst-case scenarios when the PM/O team arrives at the same time as the assault element and there is no time to sectorize the building using a detailed sectorization. The F5-B5 allows the mission commander to make assignments en route to the target building.

When using the F5-B5 method, the sides of the building are numbered one through four beginning with the front and working clockwise around the building. The front and right sides comprise the Front 5 (1+4), and the left and rear sides comprise the Back 5 (2+3).



THREAT DETECTION

The ability to identify the presence of possible threats requires an understanding of what are referred to as *target indicators*. Target indicators are features or actions that cause an object to stand out from its natural surroundings. Knowing these indicators will allow the PM/O to locate possible threats to himself, his teammates, and others present.

Shape

Shape refers to the visible outline or form of a person or object as distinguished by its surface characteristics. The PM/O should look for geometric shapes that are not common in nature, but realize that shapes may be altered to prevent recognition. This process becomes more difficult in an urban environment because of the number of manmade objects present.

Shadow

A shadow is a definite area of shade that is cast upon a surface as a result of an object intercepting the light rays that are illuminating the surface. A shadow may actually be more revealing than the object itself. Care must be taken to detect alterations of the shadow's natural shape.

Contrast

Contrast refers to the relationship of an object to its background. Contrasting shapes, colors, and textures against the natural pattern of the surrounding area may indicate the presence of a foreign body.

Color

Color can be one of the most obvious indicators in detecting the presence of foreign objects. The more the color of an object contrasts against its background, the more visible the object becomes. This is especially true when the color is not natural for that area.

Shine

Shine is a result of light reflecting off a smooth surface, causing the object to stand out conspicuously. Natural objects typically do not shine because of their rough surfaces; therefore, visible shine is usually a good indication that a manmade object is present.

Sound

Sound is a useful target indicator, especially at night when the auditory sense is compensating for the diminished visual acuity. Many times sound will reveal the location of an object long before the object can actually be seen. The ear nearest to the origin of the sound will hear the sound first and slightly louder than the opposite ear, enabling the direction of the sound to be determined.

Movement

Movement is the single most obvious target indicator. Movement alone will seldom reveal the identity of an object, but it is the most common reason objects are revealed to observing eye. This is a result of the numerous rods in the human eye that enable movement to be detected in the peripheral vision.

ELEMENTS OF OBSERVATION

Awareness

Awareness is having knowledge of something through alertness in observing or in interpreting what is seen, heard, felt, or smelt. It requires focused attention to details—taking nothing for granted. The level of awareness may be diminished by distractions, lack of interest, limited physical abilities, environmental changes, and imagination.

Understanding

Understanding is the ability to perceive the meaning of what is observed and is derived through education, training, and experience. It enhances the ability to view and consider all factors and aids in the evaluation of information.

Recording

Recording is the ability to save and recall what is observed. Mechanical aids such as writing utensils, logbooks, cameras, and tape recorders help to support recording events; however, the most accessible method of recording information is memory. The ability to record, retain, and recall information is dependant on mental capacity and the ability to discern what is essential to record.

Response

Response is the action taken toward information. A response may be as simple as recording the information in a log book or communicating the information to other team members, or as complex as firing a well-aimed shot at a deadly threat.

RECORDING INFORMATION

Range Card

A range card represents an aerial view of the target area with annotations indicating distances throughout the target area. The range card is used as a quick-reference guide to determine the range to a target within the target area.

The range card contains a sketch with determined distances to fixed objects within the target area. This information may be obtained in advance using a map of the target area, or it may be gathered on site during the operation. Once a target has been identified, the PM/O determines were it is located on the range card and then identifies the approximate range to the target using the range rings.

The range card can also be divided up into grid sectors by drawing dotted lines on the card and labeling the squares with numbers or letters. This provides the PM/O with a quick-reference guide for locating targets.

Ballistic Set Table

A ballistic set table is a companion to the range card and allows the PM/O to enter specific information about the ballistic set to the target. A *ballistic set* is a "firing solution" that factors in the range, ammunition, weather conditions, altitude, angle, and any other factor that will affect the flight of a bullet to the target.

Observation Log

An observation log is a sheet that is used to record activity during an operation. It contains a chronological record of events and gives the time, coordinates, event that took place, and actions taken or remarks.

CAMOUFLAGE

INTRODUCTION

The primary mission of the PM/O is to gather information from a concealed position. How well the PM/O will accomplish this mission will depend on his knowledge, understanding, and application of various camouflage techniques. A thorough working knowledge of camouflage and the means of detection will not only enable the PM/O to remain undetected, but will also enhance his ability to detect possible threats.

TYPES OF DETECTION

Direct Detection

Direct detection occurs when the threat observes the PM/O team moving into or occupying their forward operating position.

Indirect Detection

Indirect detection occurs when the PM/O team is compromised by sounds, scents, flagging vegetation, rising dust, or sign left behind.

TARGET INDICATORS

A target indicator refers to anything the PM/O does or fails to do that could result in detection. The objective of camouflage is to prevent recognition by allowing the PM/O to appear invisible or to induce false recognition by allowing the PM/O to be seen as a natural feature of the landscape.

Contrast

Contrast refers to the relationship of an object or person to its background. When choosing a concealment position, a background that will "absorb" the PM/O should be chosen.

Sound

Sound may be made by movement, equipment rattling, watch alarms, or talking. Some noises may be dismissed as being natural, but definite man-made sounds

(i.e. talking, radio squelch, etc.) will not. Sound is most prominent during the hours of darkness, due to enhanced auditory senses.

Before beginning an operation, a combat inspection can be made by jumping up and down and listening for rattling noises. Rattling gear may be silenced with tape or tied down with para-cord. Using slow, deliberate movements will help silence movement. Natural sounds, ambient noise, or artificial distractions can be used to mask the sound of movement by moving during such disturbances. Dogs, birds, and livestock should be avoided as much as possible.

Shape

Shape is the visible outline or form of a person or object as distinguished by its surface characteristics. The outline or form of objects can be recognized at a distance, even before the observer can identify details in their appearance. The PM/O should use camouflage that disrupts the normal shape of his equipment and person. Ghillie suits work well to accomplish this task.

Shadow

Shadow is the silhouette of an object projected against its background. It is more important to disrupt the shadow of an object than to attempt to conceal it completely. Wearing "shapeless" garments such as a boonie hat or ghillie suit, as well as attaching natural vegetation, will break up the shadow and help prevent detection.

Conversely, shadows may sometimes assist in concealment. An object in the shadow of another object is often overlooked. Moving from light to shadow or visa versa should be avoided; however, since breaking light or shadows are distinct visual cues that a threat may detect.

Texture

Rough surfaces appear darker than smooth surfaces, even if the surfaces are the same color. Under normal conditions, smooth surfaces stand out from the background; therefore, eliminating shine should take a high priority in camouflage.

Color

Color contrast between the color of an object and the color of its background can be an aid to a threat's observation. The greater the color contrast is, the more

visible the object appears. For this reason, clothing color should match the darker and lighter qualities of the background.

Color contrast becomes less important as range increases. At very long ranges, all colors tend to merge into an even tone. Poor lighting also makes it impossible for the human eye to discriminate color.

Tone

Tone is the amount of contrast between variations of the same color. Objects may become identifiable as a result of tone contrasts. Camouflage blending is the process of eliminating or reducing these contrasts by blending colors and using texture to form disruptive patterns.

Movement

Of all the target indicators, movement is the quickest and easiest to detect. The human eye is very quick to notice any movement against a stationary background. Slow regular movement is usually less obvious than fast or erratic movement. Each movement should be planned carefully.

Shine

Shine refers to the reflection of light off of a smooth surface. Skin, glass, metal, clean clothing, and similar items produce shine. These types of items must be subdued by staining, covering, or removing in order to prevent their shine from revealing the PM/O's position.

Light can be reflected off of team optics if preventative steps are not taken. A piece of fine netting or screening can be placed over the lenses of scopes and other optics to prevent reflection. The inside of the plastic scope cover cap is highly reflective when open and should be subdued.

METHODS OF CONCEALMENT

Hiding

Hiding is the complete concealment of a person or object from observation through the use of some form of physical screening. Lying in thick vegetation or under leaves are methods of hiding.

Blending

Blending is the arrangement or application of camouflage material on, over, and around an object or person in such a manner as to make the object or person appear to be part of the background.

Disrupting

Disrupting is the breaking up of an object or person's characteristic shape to avoid detection due to shape, contrast, shadow, or thermal signature.

Disguising

Disguising is the changing of physical characteristics of a person or object in such a way as to change the appearance to resemble something of lesser or greater significance.

TYPES OF CAMOUFLAGE

Natural

Natural camouflage is vegetation or materials that are native to the specific area such as mud, leaves, grass, or ash in a burnt area. These should always be used to augment appearance.

Artificial

Any material or substance produced for the purpose of coloring or covering a person or object in order to conceal it. Artificial camouflage includes ghille suits, camo netting, face paint, camouflage clothing, etc.

PERSONAL CAMOUFLAGE

Face/Skin Camouflage

There are several types of face/skin camouflage that are commercially available and come in a variety of colors. These include cammie sticks, camo compacts, grease paint, and types of facial covering.

Cammie Stick

The cammie stick is the most difficult type of face/skin paint to apply, but it also lasts the longest. Heating the stick with a flame or mixing it with bug spray will make application easier.

Camo Compact

A camo compact usually comes in a flip-open case with three or four different colors and a mirror for periodic face paint inspection. This type of face/skin paint is easier to apply than a cammie stick, but does not last as long.

Grease Paint

Grease paint comes in squeeze tubes and in a variety of colors. It is the easiest type of face/skin paint to apply, but it also comes off the easiest.

Face Veils & Neck Gaiters

Lightweight see-through face veils or neck gaiters that can be pulled over the nose and ears are also effective means of camouflaging the face and neck.

Use of Personal Camouflage

When using face/skin paint, **all** exposed skin should be covered. This includes hands (exposed wrists if using short gloves), the back of the neck, the ears, and the face. The parts of the face that naturally form shadows, such as around the eyes, under the nose and chin, should be lightened. Predominant features of the face that shine such as the forehead, cheeks, nose, and chin should be darkened. By reversing the shadows, the face will look less familiar from a distance.

Patterns and colors used for personal camouflage should blend with the natural vegetation and shadows. For jungle and woodland, use light green and loam colors. For desert, light green, brown, and sand colors should be used. For snow, white and gray colors should be used.

CLOTHING & GEAR CAMOUFLAGE

Clothing

Uniform

Various types of camouflage uniforms can be used according to team regulations. Both the terrain and the operation dictate the camouflage pattern that should be used. A good rule of thumb is to use a lighter pattern if possible. It is easier to darken the pattern (using water, mud, or paint) than it is to lighten the pattern. Black should be used sparingly, since there is very little black in nature and shadows occur naturally.

Boonie hats are good for breaking up the outline of the head. Camouflage mosquito nets or face nets are also available and can be used when face paint is not practical. Gloves should be non restrictive and should allow the wearer to operate weapons normally.

Smocks & Coveralls

Coveralls can be dyed and patterned according to terrain. Flight suits can also be used. It is best to start with light-colored material and darken to match the terrain.

Smocks can be made from sheets and are highly effective in patchy snow and desert terrain. They can be made into poncho type pullovers or oversized tops and bottoms. Smocks can be easily switched to match terrain changes. They should fit loosely enough to be removed quickly, but not so loose that they interfere with movement.

Netting & Veils

Netting can be purchased at military surplus stores, sporting good stores, and fabric stores, and is available in a variety of colors and patterns. A 5' x 5' piece of netting can be used as a veil and works well for breaking up outline and shadow. Spray paint can be used to create a break-up pattern on a solid color veil. A solid white veil works well in snow and for indoor operating positions where it allows the PM/O to blend in with the backdrop.

Due to the light and compact nature of a veil, several veils can be carried at once so that the PM/O can effectively function in any type of environment.

Ghillie Suits

Ghillie suits were originally worn by Scottish gamekeepers to count game and watch for poachers. They were also used effectively by British snipers during World War II against the highly skilled German snipers. The ghillie suit has now become a trademark of military and police snipers throughout the world.

A ghillie suit is an outer smock with irregular patterns of netting and garnishing attached to it. Netting is attached to the base garment along the neck and back to include the arms and legs. The netting is used to attach garnishing such as burlap or jute rope, and can be laced with natural vegetation. The natural vegetation must be changed often to match the area.

PM/O utilizing a ghillie suit to aid in camouflage. Note the unpainted muzzle of the rifle.

Optical Gear

Scopes and binoculars can be painted and then covered with clothing, netting, or vegetation to break up the outline and hide light reflection from objective lenses. A paper hood can be taped over objective lenses to minimize reflection. In bright light conditions, tape can be placed over lenses leaving a 1” x ½” slot to see through. Screening or mosquito netting can also be used to reduce reflection. If none of these items are available, grass can be stuffed into the lens as long as it does not obstruct the view. Whatever method is used, it should not interfere with the use of the focus rings or adjustment knobs.

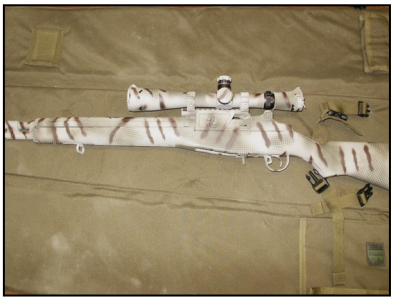
Packs & Web Gear

Web gear may be dyed, garnished, or have netting attached to aid in camouflage. Garnishing is tied to the netting and natural vegetation is attached to break up the outline. Packs can be camouflaged in the same manner.

When using netting, it should be kept to a minimum, since it can snag on trees or brush. Garnishing and vegetation should be secured so that it does not hang free.

Weapons

Long arms can be camouflaged using tape and/or spray paint. Spray paint can be applied to the stock and barrel of the weapon. Tape can be applied in strips to break up the weapon outline. Rifle wraps with netting and garnishing are also available. Rubber bands can be used to attach natural vegetation. While moving to an operating position, the sniper weapon system can be carried in a *drag bag*, which is a special rifle case made of canvas.



M14 with camouflage paint applied.

Extreme caution should be taken to ensure that weapon camouflage does not obstruct the sights or optics, and that it does not interfere with weapon operation and manipulation.

CAMOUFLAGE FOR SPECIFIC AREAS

Jungle/Woodland

In jungle or woodland areas, foliage, artificial camouflage, and personal camouflage are applied with a pattern and texture relative to the terrain. The vegetation is usually very thick, so the PM/O should make use of the natural foliage for concealment.

Desert/Urban

In sandy or urban areas textured camouflage is not necessary. The PM/O should make full use of terrain and blending colors. In a hot desert environment, light, loose fitting smocks work well due to their ability to protect the wearer from the effects of the sun and heat. In urban terrain, gray with disruptive stripes makes a good camouflage pattern. In either environment, the terrain should be used to conceal movement and routes of travel.

Snow

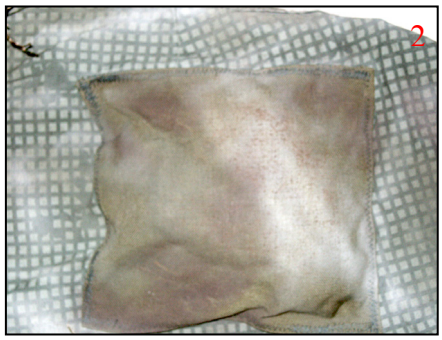
In areas of heavy snow, a full white uniform should be worn. The uniform can be improved by applying strokes of light gray spray paint to give the uniform depth. If a white uniform is not available, a white veil can be very effective. Equipment should be taped with white tape to break up the outline.

Visibility is very good on a moonlit or starry night. Movement must be made along concealed routes. Operating positions can be made almost completely invisible if selected with care.

GHILLIE SUIT ASSEMBLY

1. Select a base garment such as a loose fitting BDU top or night desert parka.

2. Reinforce elbows and other areas that may be worn down from crawling. Pieces of canvas can be glued or sewn on. Pillow stuffing can be added underneath the canvas for extra comfort and protection.



3. Subdue the base garment using spray paint. Colors such as tan, brown, gray, and olive drab should be used. Be sure to apply paint to the inside portions of the garment that might be exposed, such as the hood (if using a parka) and collar.

4. Attach netting to outside of the garment using a needle and thread and Shoe Goo®. The Shoe Goo® should be applied over the stitching on both sides of the garment in order to reinforce the stitching and prevent the netting from coming loose. The netting should cover the shoulders and back, and should cover at least half of the arm.

5. Spray paint over the Shoe Goo® after it dries to eliminate the shine.

6. Once the netting is attached to the garment, garnishing such as shredded burlap or jute rope can be tied to the netting. Camouflage burlap, which is available at most sporting goods and hunting stores, makes an ideal garnishing. The burlap is cut into 1' x 1' squares and then unwoven. The strings are then tied in bunches to the netting. Burlap can also be dyed different colors and used to break up the color pattern.

7. Once complete, a fireproof spray should be added to the suit. Scent blockers or maskers may also be added to help prevent detection from dogs and other animals.

NOTE: The above instructions are only a base guideline for making a ghillie suit. There are several different techniques and methods used for making ghillie

suits, all of which provide exceptional results. The PM/O should experiment to find which techniques work best to meet his needs.

A ghillie suit must be constantly maintained. Frequent inspection is required to ensure operational readiness. The PM/O should never be satisfied with his ghillie suit; he should be constantly making improvements.

MOVEMENT

INTRODUCTION

The mission of the PM/O requires that he be able to move in and out of a forward operating position without being detected by those he is observing. Being seen by a suspect can result is mission failure and possibly lost lives. In order to move to, from, and within a forward operating position, the PM/O must use special movement techniques that are designed to allow for movement without detection

RULES OF MOVEMENT

During movement, the PM/O should always assume that the threat area is under observation by the threat and should *stop*, *look*, *listen*, and *smell* often. All movements should be slow, deliberate, and preplanned; remembering that progress is measured in feet and inches. Whenever possible, movement should take place during disturbances such as noise, wind, or anything that will distract the suspect or mask the sound of the PM/O's movements.

INDIVIDUAL MOVEMENT TECHNIQUES

Walking

Walking is used when speed is required, good concealment is available, and suspects are not likely to be close by. When walking, the body should be bent forward with the knees bent. The knees are used as a shock absorber to avoid upper body movement. The weapon should be in line with the body with the muzzle pointed downward.

High Crawl

The high crawl can be used when some concealment is available, such as high grass or low brush. It allows the PM/O to cover distance fairly quickly while remaining unseen to the threat. When performing the high crawl, the PM/O supports his body with his knees and one hand. The weapon is carried in the other hand with the scope inside the armpit.

Medium Crawl

The medium crawl is used when concealment is limited but high enough to allow the PM/O to raise his body off the ground. The body is supported with the elbows and knees and the body is raised off the ground. The weapon is cradled inside the arms. Movement is achieved by tucking one knee, placing the opposite elbow in front of the other, and then pushing forward with the knee and elbow.

Low Crawl

The low crawl is used when concealment is limited and the PM/O needs to move quickly without being seen. The body is flat on the ground and the legs are spread apart. The weapon is held by the sling and lies across the forearm to prevent being banged against the ground. The PM/O moves by pushing with his legs and pulling with his arms.

Sniper Crawl

The sniper crawl is used when concealment is extremely limited, when suspects are close by, or when occupying a forward operating position. The body is flat on the ground and the legs are together. The weapon is held by the sling and lies across the forearm to prevent being banged against the ground. The PM/O pushes with his toes and pulls with his fingers to move across the ground.

ROUTE SELECTION

When selecting routes of movement, the PM/O should try to avoid known suspect positions and obstacles, open areas, and areas believed to be under suspect observation. He should select routes that make maximum use of cover and concealment and should use difficult terrain to his advantage.

CROSSING DANGER AREAS

Linear Danger Areas

Linear danger areas include streams, roads, streets, alleys, walkways, etc. These areas should be avoided if possible. When crossing a linear danger area, the PM/O team should try to select a point where lighting and terrain minimize exposure.

Before crossing a linear danger area, the point man should visually clear the long axis to ensure there are no visible threats. He should then identify a position of cover to move on the opposite side of the danger area.

Scrolling

Once the decision has been made to cross, the point man steps into the danger area and covers one end of the long axis with his weapon as he moves across. The instant the point man steps into the danger area, the two-man kneels at the edge and covers the opposite direction. Once the point man is across he takes a knee at the opposite edge and continues to cover the same direction. The two-man then crosses the danger area while continuing to cover his end of the long axis. This process of *scrolling* continues until all team members have crossed the danger area.

Linear Dash

If the point man, while evaluating the danger area, observes a possible firing position where a suspect could be lying in wait, the linear dash would be the safest method for getting the team across. To employ this technique, the team simply runs across the danger area simultaneously in a linear formation that runs parallel to the danger area. If there is a suspect lying in wait, chances are that the team will be across before the suspect has a chance to react.

Fences

Fences are one of the biggest obstacles to stealthy tactical movement in both rural and urban terrain. Every fence must be crossed in a tactical manner, especially when the location of suspects is not known. Of course, the safest and most

tactical method of dealing with fences is to avoid them completely, but this is not always possible.

Solid Block or Wooden Fences

Before climbing over a solid block or wooden fence, the point man should attempt to find a location where he can cover the opposite side of the fence with his weapon. After a thorough visual search of the area, the point man signals for the two-man to cross the fence while he continues to maintain security. Once the two-man is across, security becomes his responsibility while the point man and any other team members cross over.

In the event that a fence is too tall for the point man to gain a vantage point, the two-man should take a position at the base of the fence where he can physically assist the point man in gaining enough elevation to visually clear the opposite side. Once the point man is satisfied that the opposite side is clear, he can climb over and provide security while the other team members cross over.

Some fences may have strands of barbed wire or razor wire on top. These can be cut through using wire or bolt cutters. Sometimes the locals will glue shards of broken glass on top of their fences to cut anyone attempting to cross over. The tallest shards can be broken with a flashlight or knife handle. A flack vest or panel of body armor can be used to cover the top of the fence to prevent being cut.

Chain Link Fences

Chain link fences are very difficult to climb over and are often topped with barbed or razor wire. The easiest way to deal with chain link fences is to cut through them with wire or bolt cutters.

If cutting through the fence is not feasible, then the best way over is to climb up at one of the support posts. If the fence is topped with barbed wire, the corner post where there is a gap in the wire is the best place to cross.

Barbed Wire & Game Fences

Barbed wire and game fences are usually located on ranches and farms where the landowners wish to keep livestock and/or wild game located on their property.

Barbed wire fences are relatively easy to deal with and can usually be crossed by pushing down on the top strand of wire and straddling over. Newer fences will not stretch as easily and should be crossed by climbing over at a support post. Some fences may be damaged, allowing easy access between the middle strands or underneath the bottom strand.

Crossing game fences while loaded down with gear can pose a tedious task. Game fences can be very unstable and must be crossed at a support post if no other option for negotiating the fence is available.

In some instances, the bottom of the fence can be bent upward to allow the passage of gear and possibly persons underneath. Ranches with high amounts of illegal alien activity will often have ladders to allow aliens passage over the fences; however, these ladders should be considered danger areas and used only as a last resort.

LAND NAVIGATION

INTRODUCTION

The United States Border Patrol operates in both urban and rural environments, with the majority of work taking place in the latter. It is the goal of the PM/O to remain undetected in his observational position; therefore, he must be able to maneuver to his position without becoming lost or loosing his bearing. Map reading and land navigation skills are a must for the PM/O.

This section covers the information needed to read and understand a map, obtain coordinates for points on a map, and navigate to those points using the map and a compass. Land navigation is an extensive subject; therefore, only that information that is most likely to pertain to the BORTAC/SRT PM/O is covered here. If a more in-depth study into the topic is needed, an excellent source is the United States Army FM 21-26.

MAPS

A map is a scaled down graphic representation of a portion of the earth's surface, which uses colors, symbols, and labels to represent the features found on the ground.

Purpose

The purpose of a map is to permit the user to visualize an area of the earth's surface by indicating variations in terrain, the heights of natural features, the location of and distance between ground features, and the extent of vegetation.

Categories

Scale

The mathematical scale of a map is the ratio or fraction between the distance on a map and the corresponding distance on the surface of the earth. Scale is reported as a *representative fraction* with the map distance as the numerator and the ground distance as the denominator. As the denominator of the RF decreases, the scale of the map decreases.

$$RF = \frac{\text{Map Distance}}{\text{Ground Distance}}$$

Small-Scale

Maps with scales of 1:1,000,000 or smaller are classified as small-scale maps. These maps cover a very large area of land, but are less detailed. The standard small-scale map size is 1:1,000,000.

Medium-Scale

Maps with scales larger than 1:1,000,000 but smaller than 1:75,000 are classified as medium-scale maps. These maps cover a smaller amount of area and contain a moderate amount of detail. The standard medium-scale map size is 1:250,000.

Large-Scale

Maps with scales of 1:75,000 and larger are classified as large-scale maps. These maps contain the greatest amount of detail and cover the smallest amount of area. The standard large-scale map size is 1:50,000; however, 1:25,000 are also commonly used.

Type

There are several different types of maps available from a variety of different sources. Only those types that are most likely to be encountered by DRT/SRT members will be listed in this subsection.

Topographic

A topographic map is a map that shows natural and man-made features of an area by using contour lines (lines of equal elevation) to portray the size, shape, and elevation of the features. The 1:50,000-scale topographical map is the map of choice for land navigation.

Tourist Road Maps

Tourist road maps are maps of a region that show the main means of transportation and areas of interest. These maps may contain road distance and travel time between points of interest.

Terrain Model

A terrain model is a three-dimensional scale model of the terrain that provides a means for visualizing the terrain for the purpose of planning and indoctrination.

Field Sketches

A field sketch is a free-hand drawing of an area or route of travel. Field sketches are usually made during intelligence gathering operations and are used for planning an assault within a specific area.

Aerial Photographs

Aerial photographs can be used as map substitutes, or may be used to supplement existing maps of an area. Aerial photographs allow a person to analyze the layout of the terrain more precisely than if he was using a map alone.

MARGINAL INFORMATION

The margin of a map contains important information that tells about the map and how to use it. Not all maps are the same, so it is important that the user examine the marginal information carefully each time a different map is used. Listed here is a brief example of some of the basic information found on most maps.

Series Name and Scale

A map series normally consists of a common scale of maps that collectively cover a specific area. The series is generally named after the geographic or political area covered. The map scale is written as a ratio of map distance to ground distance.

Series Number

The series number is a comprehensive reference composed of four and sometimes five elements, usually four numerals or a letter and three numerals. The number is unique for the series and identifies the area and scale of the series.

Edition Number

The edition number is a specific identification based on the publication sequence of a particular map. Edition numbers run consecutively; therefore, a map labeled with a higher edition number will contain more recent information than another printing with a lower edition number.

Sheet Name

A map is usually named after an outstanding cultural or geographic feature covered within the map. The name of a cultural feature is customarily chosen; however, the geographic name may be chosen if it is better known than any cultural feature appearing on the map.

Sheet Number

Sheet numbers for large-scale maps are based on an arbitrary geographic coordinate system covering the area to be mapped. The sheet number of a 1:25,000 scale sheet is directly related to the number of a 1:50,000 scale sheet covering the same area, which in turn is directly related to the sheet number of a 1:100,000 scale sheet covering the same area. Sheet numbers for 1:250,000 and 1:1,000,000 scale maps are based on the International Map of the World (IMW) numbering system.

Unit Imprint & Symbol

The unit imprint is the signature of the agency responsible for printing the map. The unit imprint is followed by the date identifying the particular printing.

Geographic Location Name

The geographic location name indicates the country, state, or general geographic area within which the map lies. The geographic location name includes the sheet name, which is repeated in the lower margin. Large-scale maps of the United States that cover an area entirely within one county or parish, carry the county or parish name below the sheet name and geographic location name.

Symbol Legend

The symbol legend defines and illustrates the most commonly used map symbols as well as any peculiar symbols used on that particular map.

Index to Adjoining Sheets

The index to adjoining sheets, or location diagram for 1:250,000-scale maps, identifies the surrounding sheets that join with that sheet to make a complete map of the area.

Datum Notes

The horizontal, vertical, and hydrographic datum notes identify the controls used for these items on the map. Horizontal and hydrographic datum notes are usually not shown on medium and small-scale maps.

Grid Notes & Data

Maps of 1:1,000,000 and larger scale contain grid notes and a grid reference box with a sample reference to explain the grid data on the map. Maps carrying 1,000-unit-interval grid lines also display a declination diagram and a protractor scale in the margin.

TOPOGRAPHIC MAP SYMBOLS

Maps use symbols to represent natural and man-made features of the earth's surface. These symbols resemble the actual features as viewed from above and are positioned so that the center of the symbol remains in its true location. The exception to this rule would be the position of a feature adjacent to a major road. If the width of the road has been exaggerated, then the feature is moved from its true position to preserve its relation to the road.

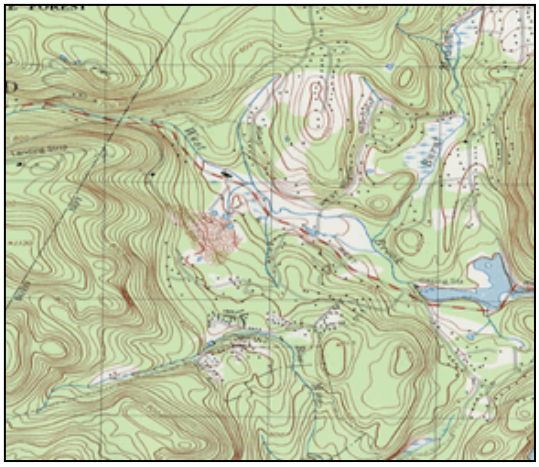
Most of the symbols used on topographic maps are standard symbols that resemble the feature they represent; however, since this is not always possible, some symbols are selected to imply the features they represent. Whenever using a new map, the legend should be referred for the symbols most commonly used on that particular topographic map sheet.

COLORS

To aid in identification of features on a map, the topographical and cultural information is usually printed in color. The colors used on a standard large-scale topographic map are listed here.

Brown

Brown identifies elevation and relief features such as contour lines.



Red

Red classifies cultural features such as main roads, built-up areas, and special features.

Blue

Blue indicates water features such as lakes, rivers, swamps, and drainage.

Green

Green identifies significant vegetation such as woods, orchards, and vineyards.

Black

Black indicates most man-made features such as buildings and roads.

Other

Other non-standard colors may be used to show special information. These colors are indicated in the map legend.

MILITARY GRID REFERENCE SYSTEM (MGRS)

A grid is a rectangular coordinate system superimposed on a map, and consists of two sets of equally spaced parallel lines that are mutually perpendicular and form a pattern of squares. The MGRS is composed of two grid systems, the Universal Transverse Mercator (UTM) and the Universal Polar Stereographic (UPS) grids. The UTM grid is designated for areas between 80° south latitude and 84° north latitude. Areas below 80° south latitude and above 84° north latitude are designated by the UPS grid system. Both grid systems use the meter as the unit of measure.

Grid Zone Designation

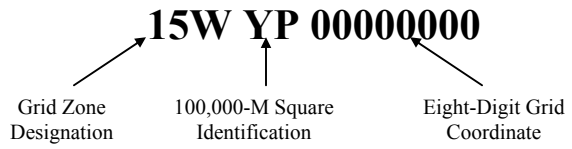
The UTM projection is divided into 60 north-south zones that are 6° wide and are numbered from east to west, 1 through 60, starting at the 180° meridian. This surface is divided into 20 east-west rows, 19 of which are 8° high and one row at the extreme north that is 12° high. These rows are lettered from north to south, C through X (I and O are omitted). The combination of zone number and row letter constitutes the *grid zone designation*.

100,000-Meter Square

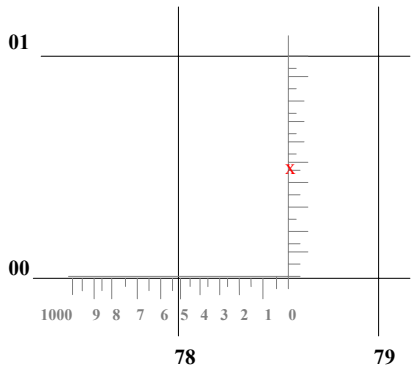
Between 84°N and 80°S, each 6° by 8° or 6° by 12° zone is comprised of 100,000-meter squares that are identified by two alphabetical letters. The first letter is the column designation; the second letter is the row designation. The 100,000-meter square identification letters are located in the grid reference box in the lower margin of the map.

Grid Coordinates

The military grid reference of a point consists of the numbers and letters indicating in which 100,000-meter square within the grid zone designation the point lies, plus the coordinates locating the point within the 100,000-meter square. Grid coordinates are expressed as follows:



A grid coordinate is obtained by placing the scale with the zero-zero mark at the lower left corner of the grid square where the point for which the coordinates are desired is located. With the horizontal line of the scale directly on top of the east-west grid line, the scale is moved to the right until the vertical line of the scale touches the point. Reading **right**, it can be determined that the point lies 530 meters to the right into the grid square, which gives a reading of **7853**. Reading **up**, it can be determined that the point lies 480



meters up into the grid square, giving an upward reading of **0045**. The grid coordinate would be written as **EH78530045**.

DISTANCE

Map Distance to Ground Distance

The ground distance between two points is determined by measuring the map distance between those points and then multiplying by the denominator of the RF. An RF of 1/50,000 means that one unit of measure on the map is equal to 50,000 units of the same measure on the ground.

GD = MD x RF Denominator

Example: The map scale is 1:50,000, which means that the RF is 1/50,000. If the map distance from point A to point B is 5 units, then 5 x 50,000 = 250,000 units of ground distance. If the map distance was measured in centimeters, then the ground distance is 250,000 cm or 2.5 kilometers.

10 millimeters = 1 centimeter
100 centimeters = 1 meter
1,000 meters = 1 kilometer

Graphic Scales

A graphic scale is a ruler that is printed on the map and is used to covert distances on the map to actual ground distances. The graphic scale is broken into two parts, the primary scale and the extension scale. The primary scale is marked in full units of measure and is to the left of the zero. The extension scale is divided into tenths and is to the left of the zero. Most maps have more than one graphic scale, each using a different unit of measure.

Pace Count

The pace count is a method for measuring ground distance while actually on the ground. To use the pace count method, the navigator must know how many paces it takes for him to walk 100 meters. To determine one's individual pace count, he must walk an accurately measured distance of 100 meters and count the number of times his left foot hits the ground before completing that distance. The pace course should be conducted on terrain similar to the terrain that will be navigated.

DIRECTION

Units of Angular Measure

Degree

The degree (°) is the most popular unit of angular measure and is subdivided into minutes (′) and seconds (″).

1 Degree = 60 Minutes
1 Minute = 60 Seconds

Mil

The mil expresses the size of an angle formed when a circle is divided into 6,400 angles, with the vertex of the angles at the center of the circle. Degrees can be converted to mils by multiplying the number of degrees by 17.78.

Mils = Degrees x 17.78

North Base Lines

True North

True north is a line from any point on the earth's surface to the North Pole. All longitudinal lines are true north lines. True north is usually represented on a map by a star.

Magnetic North

Magnetic north refers to the direction to the north magnetic pole as indicated by the north-seeking needle of a magnetic navigational instrument, such as a lensatic compass. Magnetic north is usually represented on a map by a line ending with half of an arrowhead.

Grid North

Grid north is the direction that is established by using the vertical grid lines on the map. Grid north is represented by the letters "GN" or by the letter "y."

Azimuths

An azimuth is a horizontal angle measured clockwise from a north base line (true, magnetic, or grid north). When using an azimuth, the point from which the azimuth originates is the center of an imaginary circle, which is divided into 360 degrees.

Back Azimuth

A back azimuth is the opposite direction of an azimuth. A back azimuth is obtained by adding 180° if the azimuth is 180° or less, or subtracting 180° if the azimuth is 180° or more. The back azimuth for 180° may be stated as 0° or 360°.

Magnetic Azimuth

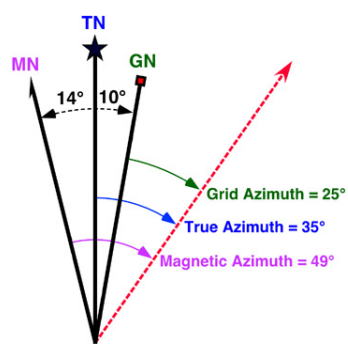
A magnetic azimuth is obtained by using a magnetic navigational instrument such as a lensatic compass.

Grid Azimuth

A grid azimuth is determined by plotting two points on a map, joining those points with a straight line, and then using a protractor to measure the angle between grid north and the line drawn.

Declination Diagram

Declination is the difference between any two norths. When using a map and compass, the declination of most importance is between magnetic north and grid north. The declination diagram found in the margin of a map shows the angular relationship between grid north, magnetic north, and true north.



Grid-Magnetic (G-M) Angle

The G-M angle is the angular size that exists between grid north and magnetic north. It is represented with an arc of dashed lines connecting the magnetic north and grid north prongs. The value is expressed to the

nearest ½ degree. The G-M angle must be accounted for when translating between grid and magnetic azimuths.

Conversion between azimuths is governed by the direction of the magnetic north prong in relation to the north grid prong. The declination diagram will have conversion notes explaining whether to add or subtract the G-M angle when converting between grid and magnetic azimuths.

Converting Magnetic to Grid

G-M angle east: MN + G-M = Grid Azimuth

G-M angle west: MN – G-M = Grid Azimuth

Converting Grid to Magnetic

G-M angle east: MN – G-M = Magnetic Azimuth

G-M angle west: MN + G-M = Magnetic Azimuth

Grid Convergence

The grid convergence notes the value of the angle for the center of the sheet given to the nearest full minute and is represented by a dashed arc connecting the grid north and true north prongs.

Intersection

Intersection refers to the process of locating the coordinates of an unknown point by successively occupying at least two known positions on the ground and then map sighting on the unknown location. This technique is used to locate the map position of distant or inaccessible objects.

First, the navigator locates and marks his position on the map, and then determines the magnetic azimuth to the unknown position using a compass. The magnetic azimuth is then converted to a grid azimuth. A line is drawn on the map along the grid azimuth from the marked position. The navigator then moves to a second location and repeats the process. The point where the two lines intersect is the location of the unknown point.

Resection

Resection refers to the process of locating one's position on a map by determining the grid azimuth to at least two well-defined locations that can be pinpointed on the map.

The navigator must first identify two distant identifiable locations on the ground and then mark them on the map. He must then determine the magnetic azimuth to one of the distant locations from his position on the ground. The magnetic azimuth is converted to grid azimuth, which is then converted to a back azimuth. A line is drawn on the map along the back azimuth from the known position back toward the navigator's position. This process is repeated for the second known location. The point where the two lines intersect is the navigator's location.

ELEVATION & RELIEF

Elevation is the vertical distance of a point on the earth's surface above or below the *datum plane*. The datum plane is the reference used for vertical measurements, and on most maps is the mean (average) sea level. **Relief** is the representation of the shape and height of landforms on the earth's surface.

Contour Lines

Contour lines are the most common method of showing elevation and relief on a standard topographic map. A contour line is an imaginary line connecting points of equal elevation and indicates a vertical distance above or below the datum plane.

Index Contour Lines

Every fifth contour line, starting from zero elevation or mean sea level, is a heavier line. The lines are called index contour lines and are usually numbered at some point denoting the elevation of that line.

Intermediate Contour Lines

The contour lines that lie between the index contour lines are finer and do not have their elevations numbered. These lines are called intermediate contour lines. There are usually four intermediate contour lines between the index contour lines.

Supplementary Contour Lines

Supplementary contour lines are dashed lines that show changes in elevation of at least one-half the contour interval. These lines are normally found where there is little change in elevation.

Contour Intervals

When determining the elevation of a point on a map, the user must know the contour interval for the map he is using. The contour interval measurement is noted in the marginal information and represents the vertical distance between adjacent contour lines.

To determine the elevation of a point, the user must find the numbered index contour line nearest to that point. He must then determine if he is increasing or decreasing in elevation and then add or subtract the number of contours to that point multiplied by the contour interval.

The elevation of a point on a hilltop can be determined by adding one-half the contour interval to the elevation value of the last contour line before the hilltop. The elevation at the bottom of a depression can be determined by subtracting one-half the contour interval from the elevation value of the lowest contour line before the depression.

Slope

Slope is expressed by comparing vertical distance to horizontal distance. Vertical distance is determined by subtracting the lowest point of the slope from the highest point.

$$VD = \text{Highest Elevation} - \text{Lowest Elevation}$$

Horizontal distance is determined by simply measuring the map distance between the two points.

Percentage of Slope

The percentage of slope is calculated by multiplying the *slope distance* by 100 and then dividing by the *horizontal distance*.

$$\text{Slope \%} = \frac{VD \times 100}{HD}$$

Slope Angle

The slope angle is expressed in degrees and is calculated by multiplying the *vertical distance* by 57.3 and then dividing that number by the *horizontal distance*.

$$\text{Slope Angle} = \frac{\text{VD} \times 5.73}{\text{HD}}$$

Terrain Features

Hill

A hill is a point or small area of high ground. From the hilltop, the ground slopes down in all directions. A hill is displayed on a map by contour lines forming concentric circles. The inside of the smallest circle is the hilltop.

Saddle

A saddle is a dip or low point between two areas of higher ground. From within a saddle there is high ground in two opposite directions and lower ground in the other two directions. A saddle is usually represented by contour lines forming an hourglass shape.

Valley

A valley is a groove in the land that is usually formed by streams or rivers. From within a valley, there is high ground in three directions (although not always obvious) and low ground in the fourth. A valley is represented by either U-shaped or V-shaped contour lines. The curve of the contour crossing always points upstream.

Ridge

A ridge is a sloping line of high ground. From the centerline of a ridge, there is low ground in three directions and high ground in one direction. All points of the ridge crest are higher than the ground on both sides of the ridge. Contour lines forming a ridge tend to be U-shaped or V-shaped with the closed end of the contour lines pointing away from higher ground.

Depression

A depression is simply a hole in the ground. It is a low point in the ground surrounded by higher ground in all directions. Depressions are represented by closed contour lines that have tick marks pointing toward low ground.

Draw

A draw is a stream course that is less developed than a valley. There is essentially no level ground within a draw and little room to maneuver. From within a draw the ground slopes upward in three directions and downward in one direction. Contour lines depicting a draw are U-shaped or V-shaped with the closed end of the contour pointing toward high ground.

Spur

A spur, which is sometimes called a finger, is a short sloping line of elevation normally projecting out from the side of a ridge. It is often formed by two roughly parallel streams cutting draws down the side of a ridge. The ground of a spur slopes downward in three directions and up in one direction. A spur is depicted by U-shaped or V-shaped contour lines with the closed end of the contour pointing away from higher ground.

Cliff

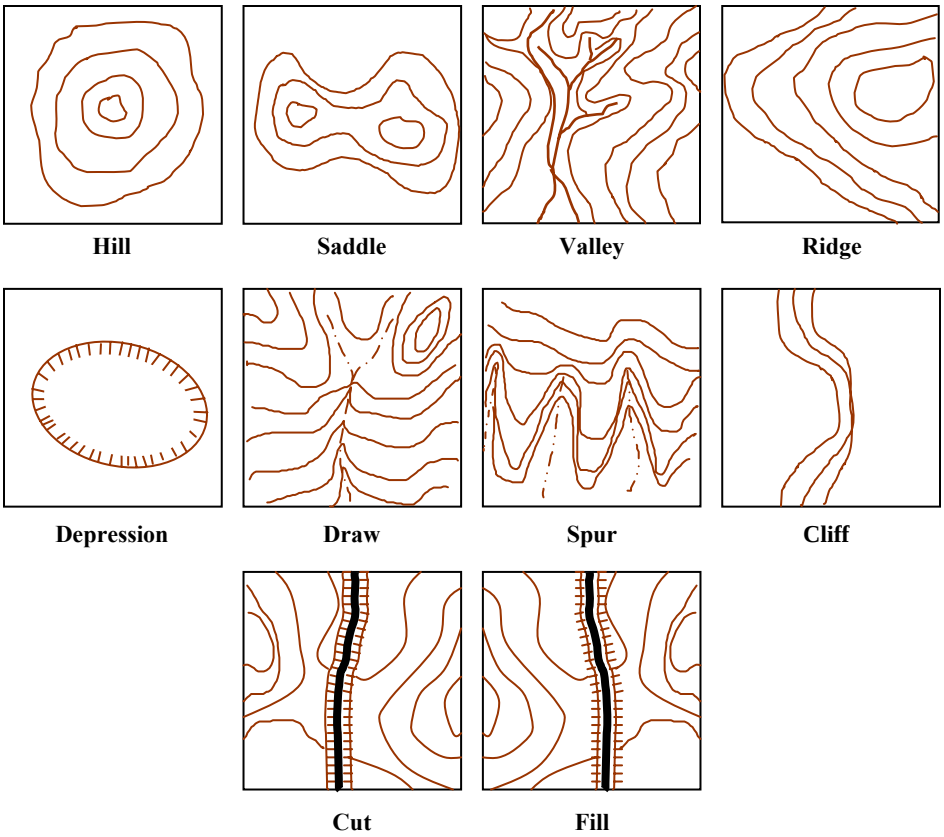
A cliff is a vertical or near vertical slope, resulting in an abrupt change of the land formation. Cliffs are depicted by contour lines very close together or even touching. When a slope is so steep that the contour lines converge, the last contour will have tick marks pointing toward the low ground.

Cut

A cut is a man-made feature resulting from cutting through raised ground, usually to form a level bed for a road or railroad track. A cut is displayed on a map by a contour line extending the length of the cut and has tick marks that extend from the cut line to the roadbed. Cuts are not shown on a map unless they are at least 10 feet high.

Fill

A fill is a man-made feature resulting from filling a low area, usually to form a level bed for a road or railroad track. A fill is displayed on a map by a contour line extending the length of the filled area and has tick marks that point toward the low ground. Fills are not shown on a map unless they are at least 10 feet deep.



Interpreting Terrain Features

A good technique for interpreting terrain features is to use the acronym ***SOSES***. Terrain features can be examined, described, and compared with each other and with corresponding map contour patterns in terms of shape, orientation, size, elevation, and slope.

Shape

Shape is the general form or outline of a feature at its base.

Orientation

Orientation refers to the general trend or direction of a feature from the navigator's viewpoint.

Size

Size is the length or width of a feature horizontally across its base.

Elevation

Elevation refers to the height of a terrain feature and can be described either in absolute or relative terms as compared to other features in the area.

Slope

Slope is the type (uniform, concave, or convex) and steepness or angle (steep or gentle) of the sides of a terrain feature.

NAVIGATION METHODS

Dead Reckoning

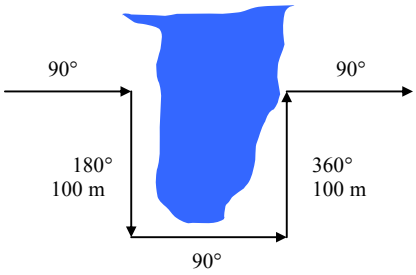
Dead reckoning begins with the determination of the direction and distance on a map from one point to another, using a protractor and graphic scales. A compass and a means of measuring distance is then used to apply this information on the ground and arrive at the desired location.

When navigating using dead reckoning, the compass is consulted at the start point and is aligned at the proper azimuth. The navigator should then sight in on a landmark that is located at the correct azimuth (called *steering marks*) and move to that point. This process is repeated as many times as necessary until arriving at the desired location.

When natural steering marks are not available, a team member can be sent out in front of the navigator to be used as steering mark. He should be sent out as far out as possible to reduce the likelihood of error.

Bypassing Obstacles

Obstacles can be bypassed by moving at right angles in an open box formation. The first and last leg of the box formation should be the same distance in order to return to the original azimuth. Only the distance of the "bottom" of the box should be factored in to the distance traveled.



Offset Technique

An offset is a deliberate magnetic deviation to the left or right of an azimuth to an objective. A deliberate offset by a known number of degrees compensates for possible errors and ensures that the navigator knows which direction he must move to reach the objective.

Terrain Association

The terrain association technique is less time consuming and more forgiving of mistakes than dead reckoning. Terrain association compares what is seen on the map to what is seen on the ground. Movements are adjusted according to the familiar landmarks encountered along the way.

FORWARD OPERATING POSITIONS

INTRODUCTION

All PM/O missions require the PM/O team to occupy some type of forward operating position from which to observe and fire if necessary. This position may be a hasty position that will only be used for a few minutes or hours, or a more permanent position that will be used for several days. Regardless of the type of position there are some basic considerations and operational guidelines that remain constant.

FOP CONSIDERATIONS

Field of Fire & Observation

The PM/O should strive for a position that provides a maximum field of fire and observation within the threat area. Typically, the further the position is from the objective the larger the field of fire and observation becomes. The distance from the objective should be balanced with the ability of the Marksman to shoot at longer ranges, the stability of the firing position, and the degree of precision that will be necessary.

Cover & Concealment

Cover and concealment provide protection from suspect fire and observation and may be natural or artificial. While cover may provide concealment, the opposite is not true of concealment. Concealment from the threat does not always mean protection from the threat.

It should be noted that when occupying an FOP the elements of cover and concealment must be compromised to a certain degree to obtain an effective field of fire. Total obscurity from the threat will usually result in the threat being totally obscured.

Avenues of Approach & Escape

There should be at least one covered route into and out of the FOP. This route is necessary to conceal the PM/O team's movement into the position, as well as to protect the withdrawal of the PM/O team in the event they are compromised, or injured during the operation.

Location

The location of the FOP should be a major consideration. A position that is too close to the threat area risks being compromised, while a position that is too far from the threat area risks becoming ineffective. Obvious positions such as water towers, ridgelines, and rooftops should be avoided. Positions that seem like the ideal FOP are the ones that are most likely to be suspected if the threat has considered the possibility of precision shooter deployment.

TYPES OF POSITIONS

Hasty Position

A hasty position is used when the PM/O team will be in position for a short period of time, when it cannot construct a position due to the proximity of the threat, or when it must immediately assume a position. It is a position from which a PM/O can observe and fire while using available cover to gain some degree of protection from the threat.

The advantage of a hasty position is that it requires no construction and can be occupied in a short amount of time. The disadvantage is that it does not allow freedom of movement, restricts observation of large areas, and offers little protection from the threat.

A hasty position should not be occupied longer than eight hours. Extended occupancy of a hasty position results in muscle fatigue combined with eye strain due to the lack of freedom of movement. This will in turn result in a loss of effectiveness.

Prepared Position

A prepared position is one that is built or improved to allow the PM/O team to observe a threat area while reducing their exposure to suspect fire and concealing them from suspect observation. It allows the PM/O team to remain in position for an extended period of time, or to be relieved in place by other PM/O teams.

A prepared position offers total freedom of movement from within the position, allowing the team members to stand, sit, or lie down. It is completely concealed and offers minimum exposure of the PM/O team, while at the same time offering a full field of view of the threat area.

OCCUPYING THE FOP

The PM/O team should establish a good, stable platform from which to provide precision fire should the need arise. When rotating observational duties, both precision weapon systems should remain in their firing positions. If the terrain around the position dictates that only one PWS may be set up in a firing position, then the weapons will be rotated accordingly.

When establishing a firing position, it is important to establish an unobstructed path from the muzzle to the target area. The PM/O should remove the bolt from the PWS and look down the barrel to ensure that there are no obstructions in front of the muzzle that may be below the line of sight and not visible through the optical sight.

It is important that the team maintain security during the setup of the FOP. While the primary Marksman is setting up his firing position, the Observer should assist him as necessary and visually study the area with either optics or the naked eye depending on the range to the target. The Observer will relay any pertinent information about the threat area to the command post or other team members. The Marksman will estimate the range to the target and make appropriate elevation and windage adjustments to his PWS.

Once the Marksman has finished setting up his firing position he will take over observation of the threat area to allow the Observer to set up the spotting scope and establish a solid observation position. If there is room to set up both rifles, then the Observer will take this time to set up his rifle as well. After the Observer has finished setting up his equipment he will assume observation of the threat area.

If there are several possible target exposure points within the threat area that vary enough in range to require different elevation settings, the Marksman should fill out a range card to reference. While the Marksman is completing the range card, the Observer should be maintaining observation and watching the wind patterns to identify an average wind condition so that the Marksman can make the proper windage adjustments to his PWS.

The PM/O team should discuss the completed range card so that both understand the information contained on the card. The range card should be placed in a location where both the Marksman and the Observer can reference it.

Rifle Rotations

Ideally, the PM/O team should consist of two or more equally trained individuals each equipped with their own PWS. Upon initial deployment, the team should decide who will function as the primary Marksman. Once on target, a rifle

rotation should be established to prevent becoming over-fatigued. The team member that is behind the rifle should be actively scanning for threats, ready to engage at a split-second's notice. For this reason, the amount of time on the rifle should be limited to about thirty minutes.

Marksman-Observer Communication

During the occupation of the FOP, the Marksman and the Observer must have a clear and effective method of communicating with each other so that any threats can be quickly identified and engaged with deadly force if necessary.

Target Indexing

When one team member locates a threat or suspect within the threat area, he should immediately relay the threat's location and description to the other team member. The location of the threat should be given first so that the other team member can begin focusing his attention in the proper direction. Locations are described using either grid sectors or clock positions and building sector labels (*See Section 7*). The other team member should repeat the location description to ensure that the directions were received correctly.

The physical description of the threat or suspect should be given after the location has been given and confirmed. Again, the other team member should repeat the physical description. Once both team members are confident that they are both looking at the same individual, a nickname should be given to that individual so that the Marksman and Observer can update each other on the individual's actions without having to give a complete physical description each time.

Target Engagement

If a threat must be engaged and the Marksman is in control of the timing of the shot, the Marksman should announce "ON TARGET" once he has indexed the target and is prepared to fire. At this time the Observer will take a final look at the wind conditions and advise the Marksman of any corrections. The Marksman will make any corrections necessary and then again announce "ON TARGET." When the Observer, who is watching the wind conditions through the spotting scope, believes that the conditions are right for the shot, he will announce "SEND IT."

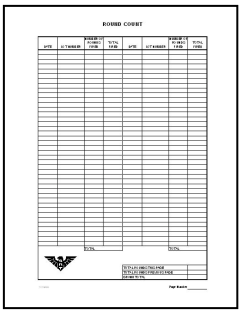
When applicable, the Observer will be watching to ensure that bystanders are clear of the area, that the threat is clear of glass or obstacles, etc. It is therefore, extremely important that the Marksman be ready to fire instantly when he says "on target." The longer it takes for the Marksman to fire after being given the command to "send it," the greater the chances are that the conditions will change.

DATA RECORDS

INTRODUCTION

The Special Operations PM/O has the important task of keeping detailed records of his training, experience, and missions. This information is important for several reasons. Every rifle performs differently under different conditions; therefore, the PM/O must record every round that comes out of his precision rifle so that he can accurately determine the nuances of his particular weapon system. Detailed records are also important for courtroom purposes. As is the standard in the law enforcement community, if it isn't written down, it didn't happen.

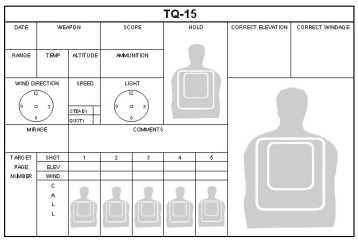
ROUND COUNT SHEET



The round count sheet is used to keep track of how many rounds, and from what lot number, have been fired out of the PM/O's issued weapon. This information is necessary for proper weapon maintenance.

A Round Count Sheet is included in Attachment 3.

DATA CARD

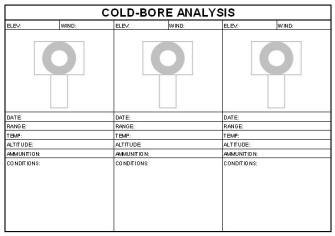


The data card is used to record firing results and all of the elements that had an affect on the firing of the weapon. These elements include range, altitude, weather conditions, lighting conditions, shooting position, ammo lot number, and any corrections made for windage or elevation. The PM/O can examine this information to help him understand how he and his particular weapon function under different conditions.

A data card contains several miniature targets representing the actual target that the PM/O is firing at. The target in the *HOLD* box is where the shooter indicates his aiming position on the target. The shooter notes the location of his reticle on the target at the instant his weapon fired in the *CALL* boxes. The actual impact location of each shot is recorded on the largest target on the data card located in the *HIT* box.

Data Cards are included in Attachment 3

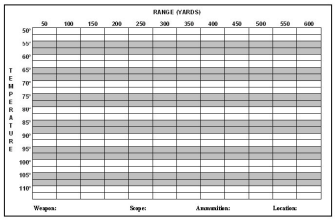
COLD-BORE ANALYSIS



One of the most important items of information that can be recorded in a data book is the weapon's cold zero. The cold zero refers to the first round that is fired out of the weapon at a given range. It is vital that the Special Operations PM/O knows his cold zero because in law enforcement situations the first shot is the most critical. The cold-bore analysis sheet allows the PM/O to consolidate his cold-bore shots for quick, easy comparison.

Cold-Bore Analysis sheets are included in Attachment 3.

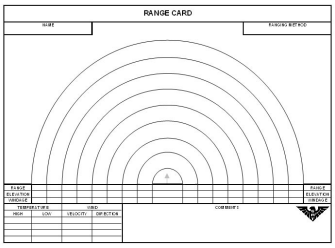
SHOT MATRIX



A shot matrix is a sheet that allows the PM/O to record necessary sighting adjustments, based on how his precision weapon system performs at different temperatures for a particular elevation. This information offers the PM/O a reference for making quick sighting adjustments for engaging targets at different ranges.

A Shot Matrix is included in Attachment 3.

RANGE CARD



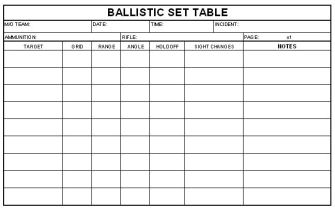
A range card represents an aerial view of a target area with annotations indicating distances throughout the target area. The range card is used as a quick-reference guide to determine the range to a target within the target area.

The range card contains a sketch with determined distances to fixed objects within the target area. This information may be obtained in advance using a map of the target area, or it may be gathered on site during the operation. Once a target has been identified, the PM/O determines were it is located on the range card and then identifies the approximate range to the target using the range rings.

The range card can also be divided up into sectors by drawing dotted lines on the card and labeling the squares with numbers or letters. This provides the PM/O with a quick-reference guide for locating targets.

A Range Card is included in Attachment 3.

BALISTIC SET TABLE



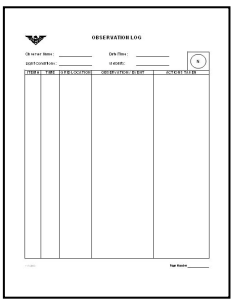
BALLISTIC SET TABLE

MO TEAM:		DATE:		TIME:		INCIDENT:
AMMUNITION:			RIFLE:			PAGE: of
TARGET	GRID	RANGE	ANGLE	HOLDOFF	SIGHT CHANGES	NOTES

A ballistic set table is a reference sheet that works in conjunction with the range card. It contains shooting solutions for targets within the target area. The PM/O records information about different locations within the area of operation and then calculates any holdoff or sighting adjustments that need to be made, based on range and environmental conditions, in order to engage threats within those areas. Since a ballistic set table contains information specific to a particular PM/O's precision weapon system, a separate ballistic set table must be completed by each PM/O operating within a PM/O Team.

A Ballistic Set Table is included in Attachment 3.

OBSERVATION LOG

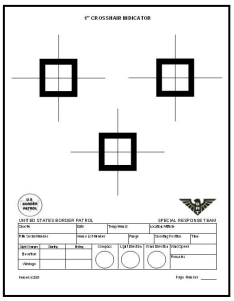


OBSERVATION LOG

An observation log is a sheet that is used to record activity during an operation. It contains a chronological record of events and gives the time, coordinates, event that took place, and actions taken or remarks.

An Observation Log is included in Attachment 3.

TARGETS



1" CROSSHAIR INDICATOR

BORTAC/SRT rifle targets are printed on 8½" x 11" paper and are designed so that the PM/O can record data at the bottom of the target. These targets should be kept in a binder and can be referenced much like the data book. The page numbers on the targets should correspond with the page numbers in the data book, so that the PM/O can easily link a page in his data book with the actual target the rounds were fired on. The advantage of keeping

the actual targets is that it is easier to see exactly where the rounds struck the target. It is also much easier to convince a jury when they can see the actual target instead of trying to decipher a data book.

The BORTAC/SRT precision rifle targets are included as Attachment 1.

PRECISION RIFLE MAINTENANCE

INTRODUCTION

The PM/O's precision rifle must be well maintained to assure that it will function properly and fire accurately should the need for precision fire arise. This is done through proper cleaning, storage, and transportation.

BREAK-IN PROCESS

The reason a new weapon must go through a breaking in process is that it is shipped from the manufacturer with the bore unpolished. The break-in process will season the bore by polishing the barrel surface under heat and pressure. The following steps are recommended for breaking in rifles with stainless steal barrels:

1. Fire one round through the clean bore.

2. Moisten a patch with Shooter's Choice and push it through the barrel using a cleaning rod and a jag, then push a dry patch through the bore. Repeat steps 1 and 2 for a total of five cycles.

3. Fire three rounds and then clean the barrel according to the recommended cleaning procedure outlined later in this section. Repeat this process for a total of five cycles.

4. Fire five rounds and then clean the barrel according to the recommended cleaning procedure outlined later in this section. Repeat this process for a total of two cycles.

   NOTE: To maximize barrel life, it is recommended that the shooter fire no more than 20 rounds through the rifle between cleanings, once the rifle has been broken in.

CLEANING

Thorough cleaning increases the longevity of the rifle, as well as the accuracy and consistency of rounds fired through it. Inadequate cleaning will diminish accuracy and limit the life of the barrel by 25-50 percent.

Recommended Cleaning Supplies

- Full length Dewey cleaning rod
- Brass jag
- Bore guide
- Chamber brush
- Lug recess cleaning tool
- Bolt disassembly tool
- Brass bore brush
- Shooter's Choice bore cleaner
- Plastic leak-proof bottles with flip down nozzles
- Gun grease
- Clean lint-free rags
- Cotton cleaning patches
- Chamber cleaning patches
- Rem Oil
- Alcohol
- CLP
- Cotton swabs
- Nylon cleaning brush

Bore Cleaning Procedure

A properly cleaned bore can improve rifle accuracy by ¼ MOA or more. A dirty bore and chamber will speed up corrosion. To ensure accuracy and to prevent corrosion, the following cleaning procedure should be utilized:

1. Elevate the stock of the rifle so that the barrel is angled downward.

2. Remove the bolt assembly and place a rag over the comb of the stock just behind the receiver to prevent fluids from entering between the receiver and the stock. Fluids between the stock and the receiver will cause a sliding effect during recoil, resulting in decreased accuracy and increased wear on the receiver and bedding material.

3. Insert the bore guide into the breach

4. Moisten a patch with Shooter's Choice and push it through the barrel using a cleaning rod and a jag to remove any loose fowling in the bore. Remove the patch before pulling the rod back through the barrel.

5. Coat a brass bore brush with Shooter's Choice and run it through the barrel 8-10 times. Be sure not to hit the crown when pulling the brush back through. This can damage the crown, resulting in uneven muzzle pressure and diminished accuracy.

6. Repeat steps 4 and 5 two times, or until the barrel is clean.

7. Moisten three patches with Shooter's Choice and push them through the barrel one at a time.

   NOTE: During the cleaning process, wipe the cleaning rod with a dry rag after each pass through the barrel to prevent putting fowling back in the bore. Also, be sure to wipe dripping solvent off of the crown.

8. Allow the weapon to sit for 10-15 minutes.

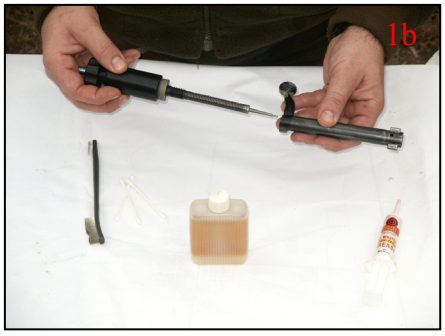
9. Push dry patches through the barrel until the patches come out unsoiled.

   NOTE: Clean bore brush with alcohol after use to avoid introducing more fowling into the bore. Store bore brushes, jags, and bore guide in plastic containers to keep them clean when not in use.

Bolt Assembly Cleaning Procedure

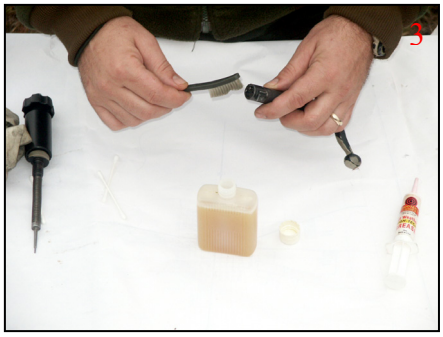
Proper cleaning and lubrication of the bolt assembly will ensure smooth operation and will reduce the possibility of extractor and firing pin malfunctions. The following process should be used to clean bolt assembly:

1. Remove the firing pin mechanism using the bolt disassembly tool.



2. Wipe down the firing pin mechanism with a clean rag.

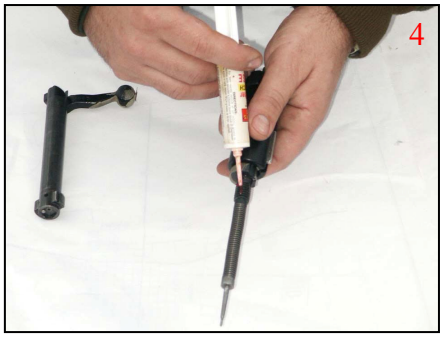
3. Scrub the bolt with CLP and a nylon brush and wipe clean. Pay special attention to the bolt face and the extractor, where grit and brass tend to accumulate.



4. Place a small bead of gun grease on the threads of the bolt.

5. Reassemble the bolt assembly. Ensure that the cocking cam locks into the bolt. Failure to do so will render the weapon inoperable.

6. Place a small amount of gun grease on the back side of the bolt lugs.



Chamber Cleaning Procedure

Use the following procedure for cleaning the chamber:

1. Attach a patch moistened with Shooter's Choice to the lug recess cleaning tool.

2. Insert the cleaning tool into the chamber and twist several times.

3. Repeat steps 1 and 2 using dry patches until a patch comes out unsoiled.

STORAGE

Before a weapon is stored it should be carefully cleaned and thoroughly oiled. A patch moistened with lubricant should be run through the barrel. This will lubricate the bore and protect it from corrosion. Lubricant inside the bore can cause muzzle pressure to vary when the weapon is fired. Running a dry patch through the barrel before firing a weapon out of storage will remove any lubricant and increase first-round accuracy.

Stored weapons should be hung upside down with the lens caps open. Spring tension should be relieved by firing the weapon on an empty chamber. Access to the weapon should be limited to the individual to whom the weapon is assigned.

An inactive weapon is a weapon that remains stored for a period of 90 days or longer. Regardless of whether or not the weapon is assigned to an individual, an inactive weapon should be cleaned and inspected every 90 days to prevent corrosion and to detect worn or damaged parts that may need to be repaired or replaced.

TRANSPORTATION

During non-tactical operations the weapon system should be transported in a locked protective hard-case. The case should be airline approved for transportation on commercial airplanes.

During tactical operations when the weapon is being carried in a drag bag, a scope cover and crown cover should be used to prevent damage to those areas.

Scope Cover

Crown Cover

CHARTS & TABLES

Minutes of Angle to Inches A-2

Length to Minutes of Angle A-4

Mil Conversion Tables (Meters) A-9

Mil Conversion Tables (Yards) A-11

Wind Constants A-13

Ballistic Tables A-17

Wind Correction Tables A-26

1 Mil Equivalency Table A-37

MINUTES OF ANGLE TO INCHES
½-5 MOA, 100-1,000 Yards

	MINUTES OF ANGLE									
YARDS	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**
100	0.524	1.047	1.571	2.094	2.618	3.141	3.665	4.188	4.712	5.235
150	0.785	1.571	2.356	3.141	3.926	4.712	5.497	6.282	7.067	7.853
200	1.047	2.094	3.141	4.188	5.235	6.282	7.329	8.376	9.423	10.470
250	1.309	2.618	3.926	5.235	6.544	7.853	9.161	10.470	11.779	13.088
300	1.571	3.141	4.712	6.282	7.853	9.423	10.994	12.564	14.135	15.705
350	1.832	3.665	5.497	7.329	9.161	10.994	12.826	14.658	16.490	18.323
400	2.094	4.188	6.282	8.376	10.470	12.564	14.658	16.752	18.846	20.940
450	2.356	4.712	7.067	9.423	11.779	14.135	16.490	18.846	21.202	23.558
500	2.618	5.235	7.853	10.470	13.088	15.705	18.323	20.940	23.558	26.175
550	2.879	5.759	8.638	11.517	14.396	17.276	20.155	23.034	25.913	28.793
600	3.141	6.282	9.423	12.564	15.705	18.846	21.987	25.128	28.269	31.410
650	3.403	6.806	10.208	13.611	17.014	20.417	23.819	27.222	30.625	34.028
700	3.665	7.329	10.994	14.658	18.323	21.987	25.652	29.316	32.981	36.645
750	3.926	7.853	11.779	15.705	19.631	23.558	27.484	31.410	35.336	39.263
800	4.188	8.376	12.564	16.752	20.940	25.128	29.316	33.504	37.692	41.880
850	4.450	8.900	13.349	17.799	22.249	26.699	31.148	35.598	40.048	44.498
900	4.712	9.423	14.135	18.846	23.558	28.269	32.981	37.692	42.404	47.115
950	4.973	9.947	14.920	19.893	24.866	29.840	34.813	39.786	44.759	49.733
1,000	5.235	10.470	15.705	20.940	26.175	31.410	36.645	41.880	47.115	52.350

1 MOA = 1.0472 inches at 100 yards

MINUTES OF ANGLE TO INCHES
5½-10 MOA, 100-1,000 Yards

	MINUTES OF ANGLE									
YARDS	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**
100	5.759	6.282	6.806	7.329	7.853	8.376	8.900	9.423	9.947	10.470
150	8.638	9.423	10.208	10.994	11.779	12.564	13.349	14.135	14.920	15.705
200	11.517	12.564	13.611	14.658	15.705	16.752	17.799	18.846	19.893	20.940
250	14.396	15.705	17.014	18.323	19.631	20.940	22.249	23.558	24.866	26.175
300	17.276	18.846	20.417	21.987	23.558	25.128	26.699	28.269	29.840	31.410
350	20.155	21.987	23.819	25.652	27.484	29.316	31.148	32.981	34.813	36.645
400	23.034	25.128	27.222	29.316	31.410	33.504	35.598	37.692	39.786	41.880
450	25.913	28.269	30.625	32.981	35.336	37.692	40.048	42.404	44.759	47.115
500	28.793	31.410	34.028	36.645	39.263	41.880	44.498	47.115	49.733	52.350
550	31.672	34.551	37.430	40.310	43.189	46.068	48.947	51.827	54.706	57.585
600	34.551	37.692	40.833	43.974	47.115	50.256	53.397	56.538	59.679	62.820
650	37.430	40.833	44.236	47.639	51.041	54.444	57.847	61.250	64.652	68.055
700	40.310	43.974	47.639	51.303	54.968	58.632	62.297	65.961	69.626	73.290
750	43.189	47.115	51.041	54.968	58.894	62.820	66.746	70.673	74.599	78.525
800	46.068	50.256	54.444	58.632	62.820	67.008	71.196	75.384	79.572	83.760
850	48.947	53.397	57.847	62.297	66.746	71.196	75.646	80.096	84.545	88.995
900	51.827	56.538	61.250	65.961	70.673	75.384	80.096	84.807	89.519	94.230
950	54.706	59.679	64.652	69.626	74.599	79.572	84.545	89.519	94.492	99.465
1,000	57.585	62.820	68.055	73.290	78.525	83.760	88.995	94.230	99.465	104.700

1 MOA = 1.0472 inches at 100 yards

LENGTH TO MINUTES OF ANGLE

½-5 Feet, 50-1,000 Yards

DISTANCE (YARDS)										
YARDS	**0.17**	**0.33**	**0.50**	**0.67**	**0.83**	**1.00**	**1.17**	**1.33**	**1.50**	**1.67**
FEET	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**2.5**	**4.0**	**4.5**	**5.0**
INCHES	**6**	**12**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
1000	0.6	1.3	1.9	2.5	3.1	3.8	4.4	5.0	5.7	6.3
950	0.7	1.3	2.0	2.6	3.3	4.0	4.6	5.3	6.0	6.6
900	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	7.0
850	0.7	1.5	2.2	3.0	3.7	4.4	5.2	5.9	6.7	7.4
800	0.8	1.6	2.4	3.1	3.9	4.7	5.5	6.3	7.1	7.9
750	0.8	1.7	2.5	3.4	4.2	5.0	5.9	6.7	7.5	8.4
700	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1	9.0
650	1.0	1.9	2.9	3.9	4.8	5.8	6.8	7.7	8.7	9.7
600	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.4	9.4	10.5
550	1.1	2.3	3.4	4.6	5.7	6.9	8.0	9.1	10.3	11.4
500	1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.1	11.3	12.6
450	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0
400	1.6	3.1	4.7	6.3	7.9	9.4	11.0	12.6	14.1	15.7
350	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2	18.0
300	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.8	20.9
250	2.5	5.0	7.5	10.1	12.6	15.1	17.6	20.1	22.6	25.1
200	3.1	6.3	9.4	12.6	15.7	18.8	22.0	25.1	28.3	31.4
150	4.2	8.4	12.6	16.8	20.9	25.1	29.3	33.5	37.7	
100	6.3	12.6	18.8	25.1	31.4	37.7				
50	12.6	25.1	37.7							

$$MOA = \frac{L \times 104.72}{D} \qquad L = \frac{MOA \times D}{104.72} \qquad D = \frac{L \times 104.72}{MOA}$$

D = Distance in Yards
L = Length in Inches

LENGTH TO MINUTES OF ANGLE

5½-10 Feet, 50-1,000 Yards

DISTANCE (YARDS)										
YARDS	**1.83**	**2.00**	**2.17**	**2.33**	**2.50**	**2.67**	**2.83**	**3.00**	**3.17**	**3.33**
FEET	**5.5**	**6.0**	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**
INCHES	**66**	**72**	**78**	**84**	**90**	**96**	**102**	**108**	**114**	**120**
1000	6.9	7.5	8.2	8.8	9.4	10.1	10.7	11.3	11.9	12.6
950	7.3	7.9	8.6	9.3	9.9	10.6	11.2	11.9	12.6	13.2
900	7.7	8.4	9.1	9.8	10.5	11.2	11.9	12.6	13.3	14.0
850	8.1	8.9	9.6	10.3	11.1	11.8	12.6	13.3	14.0	14.8
800	8.6	9.4	10.2	11.0	11.8	12.6	13.4	14.1	14.9	15.7
750	9.2	10.1	10.9	11.7	12.6	13.4	14.2	15.1	15.9	16.8
700	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2	17.1	18.0
650	10.6	11.6	12.6	13.5	14.5	15.5	16.4	17.4	18.4	19.3
600	11.5	12.6	13.6	14.7	15.7	16.8	17.8	18.8	19.9	20.9
550	12.6	13.7	14.9	16.0	17.1	18.3	19.4	20.6	21.7	22.8
500	13.8	15.1	16.3	17.6	18.8	20.1	21.4	22.6	23.9	25.1
450	15.4	16.8	18.2	19.5	20.9	22.3	23.7	25.1	26.5	27.9
400	17.3	18.8	20.4	22.0	23.6	25.1	26.7	28.3	29.8	31.4
350	19.7	21.5	23.3	25.1	26.9	28.7	30.5	32.3	34.1	35.9
300	23.0	25.1	27.2	29.3	31.4	33.5	35.6	37.7		
250	27.6	30.2	32.7	35.2	37.7					
200	34.6	37.7								
150										
100										
50										

$$MOA = \frac{L \times 104.72}{D} \qquad L = \frac{MOA \times D}{104.72} \qquad D = \frac{L \times 104.72}{MOA}$$

D = Distance in Yards
L = Length in Inches

LENGTH TO MINUTES OF ANGLE

½-5 Inches, 25-500 Yards

DISTANCE (YARDS)	FEET	0.04	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42
	INCHES	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
	500	0.10	0.21	0.31	0.42	0.52	0.63	0.73	0.84	0.94	1.05
	475	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10
	450	0.12	0.23	0.35	0.47	0.58	0.70	0.81	0.93	1.05	1.16
	425	0.12	0.25	0.37	0.49	0.62	0.74	0.86	0.99	1.11	1.23
	400	0.13	0.26	0.39	0.52	0.65	0.79	0.92	1.05	1.18	1.31
	375	0.14	0.28	0.42	0.56	0.70	0.84	0.98	1.12	1.26	1.40
	350	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50
	325	0.16	0.32	0.48	0.64	0.81	0.97	1.13	1.29	1.45	1.61
	300	0.17	0.35	0.52	0.70	0.87	1.05	1.22	1.40	1.57	1.75
	275	0.19	0.38	0.57	0.76	0.95	1.14	1.33	1.52	1.71	1.90
	250	0.21	0.42	0.63	0.84	1.05	1.26	1.47	1.68	1.88	2.09
	225	0.23	0.47	0.70	0.93	1.16	1.40	1.63	1.86	2.09	2.33
	200	0.26	0.52	0.79	1.05	1.31	1.57	1.83	2.09	2.36	2.62
	175	0.30	0.60	0.90	1.20	1.50	1.80	2.09	2.39	2.69	2.99
	150	0.35	0.70	1.05	1.40	1.75	2.09	2.44	2.79	3.14	3.49
	125	0.42	0.84	1.26	1.68	2.09	2.51	2.93	3.35	3.77	4.19
	100	0.52	1.05	1.57	2.09	2.62	3.14	3.67	4.19	4.71	5.24
	75	0.70	1.40	2.09	2.79	3.49	4.19	4.89	5.59	6.28	6.98
	50	1.05	2.09	3.14	4.19	5.24	6.28	7.33	8.38	9.42	10.47
	25	2.09	4.19	6.28	8.38	10.47	12.57	14.66	16.76	18.85	20.94

$$MOA = \frac{L \times 104.72}{D} \qquad L = \frac{MOA \times D}{104.72} \qquad D = \frac{L \times 104.72}{MOA}$$

D = Distance in Yards
L = Length in Inches

LENGTH TO MINUTES OF ANGLE

5½-10 Inches, 25-500 Yards

DISTANCE (YARDS)	FEET	0.46	0.50	0.54	0.58	0.63	0.67	0.71	0.75	0.79	0.83
	INCHES	5.5	6.0	6.5	7.0	7.5	8.0	8.8	9.0	9.5	10.0
	500	1.15	1.26	1.36	1.47	1.57	1.68	1.84	1.88	1.99	2.09
	475	1.21	1.32	1.43	1.54	1.65	1.76	1.94	1.98	2.09	2.20
	450	1.28	1.40	1.51	1.63	1.75	1.86	2.05	2.09	2.21	2.33
	425	1.36	1.48	1.60	1.72	1.85	1.97	2.17	2.22	2.34	2.46
	400	1.44	1.57	1.70	1.83	1.96	2.09	2.30	2.36	2.49	2.62
	375	1.54	1.68	1.82	1.95	2.09	2.23	2.46	2.51	2.65	2.79
	350	1.65	1.80	1.94	2.09	2.24	2.39	2.63	2.69	2.84	2.99
	325	1.77	1.93	2.09	2.26	2.42	2.58	2.84	2.90	3.06	3.22
	300	1.92	2.09	2.27	2.44	2.62	2.79	3.07	3.14	3.32	3.49
	275	2.09	2.28	2.48	2.67	2.86	3.05	3.35	3.43	3.62	3.81
	250	2.30	2.51	2.72	2.93	3.14	3.35	3.69	3.77	3.98	4.19
	225	2.56	2.79	3.03	3.26	3.49	3.72	4.10	4.19	4.42	4.65
	200	2.88	3.14	3.40	3.67	3.93	4.19	4.61	4.71	4.97	5.24
	175	3.29	3.59	3.89	4.19	4.49	4.79	5.27	5.39	5.68	5.98
	150	3.84	4.19	4.54	4.89	5.24	5.59	6.14	6.28	6.63	6.98
	125	4.61	5.03	5.45	5.86	6.28	6.70	7.37	7.54	7.96	8.38
	100	5.76	6.28	6.81	7.33	7.85	8.38	9.22	9.42	9.95	10.47
	75	7.68	8.38	9.08	9.77	10.47	11.17	12.29	12.57	13.26	13.96
	50	11.52	12.57	13.61	14.66	15.71	16.76	18.43	18.85	19.90	20.94
	25	23.04	25.13	27.23	29.32	31.42	33.51	36.86	37.70	39.79	41.89

$$MOA = \frac{L \times 104.72}{D} \qquad L = \frac{MOA \times D}{104.72} \qquad D = \frac{L \times 104.72}{MOA}$$

D = Distance in Yards
L = Length in Inches

LENGTH TO MINUTES OF ANGLE

10½-12 Inches, 25-500 Yards

DISTANCE (YARDS)	FEET	0.88	0.92	0.96	1.00	0.88
	INCHES	10.5	11.0	11.5	12.0	10.5
	500	2.20	2.30	2.41	2.51	2.20
	475	2.31	2.43	2.54	2.65	2.31
	450	2.44	2.56	2.68	2.79	2.44
	425	2.59	2.71	2.83	2.96	2.59
	400	2.75	2.88	3.01	3.14	2.75
	375	2.93	3.07	3.21	3.35	2.93
	350	3.14	3.29	3.44	3.59	3.14
	325	3.38	3.54	3.71	3.87	3.38
	300	3.67	3.84	4.01	4.19	3.67
	275	4.00	4.19	4.38	4.57	4.00
	250	4.40	4.61	4.82	5.03	4.40
	225	4.89	5.12	5.35	5.59	4.89
	200	5.50	5.76	6.02	6.28	5.50
	175	6.28	6.58	6.88	7.18	6.28
	150	7.33	7.68	8.03	8.38	7.33
	125	8.80	9.22	9.63	10.05	8.80
	100	11.00	11.52	12.04	12.57	11.00
	75	14.66	15.36	16.06	16.76	14.66
	50	21.99	23.04	24.09	25.13	21.99
	25	43.98	46.08	48.17	50.27	43.98

$$MOA = \frac{L \times 104.72}{D} \qquad L = \frac{MOA \times D}{104.72} \qquad D = \frac{L \times 104.72}{MOA}$$

D = Distance in Yards
L = Length in Inches

MIL CONVERSION TABLE (METERS)
2-20 Inches, .75-10 Mils

MILS	YARDS	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.56
	INCHES	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
	0.75	68	135	203	271	339	406	474	542	610	677
	1.00	51	102	152	203	254	305	356	406	457	508
	1.25	41	81	122	163	203	244	284	325	366	406
	1.50	34	68	102	135	169	203	237	271	305	339
	1.75	29	58	87	116	145	174	203	232	261	290
	2.00	25	51	76	102	127	152	178	203	229	254
	2.25	23	45	68	90	113	135	158	181	203	226
	2.50	20	41	61	81	102	122	142	163	183	203
	2.75	18	37	55	74	92	111	129	148	166	185
	3.00	17	34	51	68	85	102	119	135	152	169
	3.25	16	31	47	63	78	94	109	125	141	156
	3.50	15	29	44	58	73	87	102	116	131	145
	3.75	14	27	41	54	68	81	95	108	122	135
	4.00	13	25	38	51	64	76	89	102	114	127
	4.25	12	24	36	48	60	72	84	96	108	120
	4.50	11	23	34	45	56	68	79	90	102	113
	4.75	11	21	32	43	53	64	75	86	96	107
	5.00	10	20	30	41	51	61	71	81	91	102
	5.25	10	19	29	39	48	58	68	77	87	97
	5.50	9	18	28	37	46	55	65	74	83	92
	5.75	9	18	27	35	44	53	62	71	80	88
	6.00	8	17	25	34	42	51	59	68	76	85
	6.25	8	16	24	33	41	49	57	65	73	81
	6.50	8	16	23	31	39	47	55	63	70	78
	6.75	8	15	23	30	38	45	53	60	68	75
	7.00	7	15	22	29	36	44	51	58	65	73
	7.25	7	14	21	28	35	42	49	56	63	70
	7.50	7	14	20	27	34	41	47	54	61	68
	7.75	7	13	20	26	33	39	46	52	59	66
	8.00	6	13	19	25	32	38	44	51	57	64
	8.25	6	12	18	25	31	37	43	49	55	62
	8.50	6	12	18	24	30	36	42	48	54	60
	8.75	6	12	17	23	29	35	41	46	52	58
	9.00	6	11	17	23	28	34	40	45	51	56
	9.25	5	11	16	22	27	33	38	44	49	55
	9.50	5	11	16	21	27	32	37	43	48	53
	9.75	5	10	16	21	26	31	36	42	47	52
	10.00	5	10	15	20	25	30	36	41	46	51

$$\frac{\text{Size (Meters)} \times 1{,}000}{\text{MILS}} = \text{Distance (Meters)}$$

$$\frac{\text{Size (Inches)} \times 25.4}{\text{MILS}} = \text{Distance (Meters)}$$

MIL CONVERSION TABLE (METERS)
22-90 Inches, .75-10 Mils

MILS	YARDS	0.61	0.67	0.72	0.78	0.83	0.89	1.00	1.50	2.00	2.50
	INCHES	22	24	26	28	30	32	36	54	72	90
	0.75	745	813	881	948	1016	1084	1219	1829	2438	3048
	1.00	559	610	660	711	762	813	914	1372	1829	2286
	1.25	447	488	528	569	610	650	732	1097	1463	1829
	1.50	373	406	440	474	508	542	610	914	1219	1524
	1.75	319	348	377	406	435	464	523	784	1045	1306
	2.00	279	305	330	356	381	406	457	686	914	1143
	2.25	248	271	294	316	339	361	406	610	813	1016
	2.50	224	244	264	284	305	325	366	549	732	914
	2.75	203	222	240	259	277	296	333	499	665	831
	3.00	186	203	220	237	254	271	305	457	610	762
	3.25	172	188	203	219	234	250	281	422	563	703
	3.50	160	174	189	203	218	232	261	392	523	653
	3.75	149	163	176	190	203	217	244	366	488	610
	4.00	140	152	165	178	191	203	229	343	457	572
	4.25	131	143	155	167	179	191	215	323	430	538
	4.50	124	135	147	158	169	181	203	305	406	508
	4.75	118	128	139	150	160	171	193	289	385	481
	5.00	112	122	132	142	152	163	183	274	366	457
	5.25	106	116	126	135	145	155	174	261	348	435
	5.50	102	111	120	129	139	148	166	249	333	416
	5.75	97	106	115	124	133	141	159	239	318	398
	6.00	93	102	110	119	127	135	152	229	305	381
	6.25	89	98	106	114	122	130	146	219	293	366
	6.50	86	94	102	109	117	125	141	211	281	352
	6.75	83	90	98	105	113	120	135	203	271	339
	7.00	80	87	94	102	109	116	131	196	261	327
	7.25	77	84	91	98	105	112	126	189	252	315
	7.50	75	81	88	95	102	108	122	183	244	305
	7.75	72	79	85	92	98	105	118	177	236	295
	8.00	70	76	83	89	95	102	114	171	229	286
	8.25	68	74	80	86	92	99	111	166	222	277
	8.50	66	72	78	84	90	96	108	161	215	269
	8.75	64	70	75	81	87	93	105	157	209	261
	9.00	62	68	73	79	85	90	102	152	203	254
	9.25	60	66	71	77	82	88	99	148	198	247
	9.50	59	64	70	75	80	86	96	144	193	241
	9.75	57	63	68	73	78	83	94	141	188	234
	10.00	56	61	66	71	76	81	91	137	183	229

$$\frac{\text{Size (Meters)} \times 1{,}000}{\text{MILS}} = \text{Distance (Meters)}$$

$$\frac{\text{Size (Inches)} \times 25.4}{\text{MILS}} = \text{Distance (Meters)}$$

MIL CONVERSION TABLE (YARDS)

2-20 Inches, .75-10 Mils

MILS	YARDS	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.56
	INCHES	2	4	6	8	10	12	14	16	18	20
	0.75	74	148	222	296	370	444	518	592	666	741
	1.00	56	111	167	222	278	333	389	444	500	555
	1.25	44	89	133	178	222	267	311	355	400	444
	1.50	37	74	111	148	185	222	259	296	333	370
	1.75	32	63	95	127	159	190	222	254	286	317
	2.00	28	56	83	111	139	167	194	222	250	278
	2.25	25	49	74	99	123	148	173	197	222	247
	2.50	22	44	67	89	111	133	156	178	200	222
	2.75	20	40	61	81	101	121	141	162	182	202
	3.00	19	37	56	74	93	111	130	148	167	185
	3.25	17	34	51	68	85	103	120	137	154	171
	3.50	16	32	48	63	79	95	111	127	143	159
	3.75	15	30	44	59	74	89	104	118	133	148
	4.00	14	28	42	56	69	83	97	111	125	139
	4.25	13	26	39	52	65	78	91	105	118	131
	4.50	12	25	37	49	62	74	86	99	111	123
	4.75	12	23	35	47	58	70	82	94	105	117
	5.00	11	22	33	44	56	67	78	89	100	111
	5.25	11	21	32	42	53	63	74	85	95	106
	5.50	10	20	30	40	50	61	71	81	91	101
	5.75	10	19	29	39	48	58	68	77	87	97
	6.00	9	19	28	37	46	56	65	74	83	93
	6.25	9	18	27	36	44	53	62	71	80	89
	6.50	9	17	26	34	43	51	60	68	77	85
	6.75	8	16	25	33	41	49	58	66	74	82
	7.00	8	16	24	32	40	48	56	63	71	79
	7.25	8	15	23	31	38	46	54	61	69	77
	7.50	7	15	22	30	37	44	52	59	67	74
	7.75	7	14	21	29	36	43	50	57	64	72
	8.00	7	14	21	28	35	42	49	56	62	69
	8.25	7	13	20	27	34	40	47	54	61	67
	8.50	7	13	20	26	33	39	46	52	59	65
	8.75	6	13	19	25	32	38	44	51	57	63
	9.00	6	12	19	25	31	37	43	49	56	62
	9.25	6	12	18	24	30	36	42	48	54	60
	9.50	6	12	18	23	29	35	41	47	53	58
	9.75	6	11	17	23	28	34	40	46	51	57
	10.00	6	11	17	22	28	33	39	44	50	56

$$\frac{\text{Size (Yards)} \times 1{,}000}{\text{MILS}} = \text{Distance (Yards)}$$

$$\frac{\text{Size (Inches)} \times 27.77}{\text{MILS}} = \text{Distance (Yards)}$$

MIL CONVERSION TABLE (YARDS)
22-90 Inches, .75-10 Mils

MILS	YARDS	0.61	0.67	0.72	0.78	0.83	0.89	1.00	1.50	2.00	2.50
	INCHES	**22**	**24**	**26**	**28**	**30**	**32**	**36**	**54**	**72**	**90**
	0.75	815	889	963	1037	1111	1185	1333	1999	2666	3332
	1.00	611	666	722	778	833	889	1000	1500	1999	2499
	1.25	489	533	578	622	666	711	800	1200	1600	1999
	1.50	407	444	481	518	555	592	666	1000	1333	1666
	1.75	349	381	413	444	476	508	571	857	1143	1428
	2.00	305	333	361	389	417	444	500	750	1000	1250
	2.25	272	296	321	346	370	395	444	666	889	1111
	2.50	244	267	289	311	333	355	400	600	800	1000
	2.75	222	242	263	283	303	323	364	545	727	909
	3.00	204	222	241	259	278	296	333	500	666	833
	3.25	188	205	222	239	256	273	308	461	615	769
	3.50	175	190	206	222	238	254	286	428	571	714
	3.75	163	178	193	207	222	237	267	400	533	666
	4.00	153	167	181	194	208	222	250	375	500	625
	4.25	144	157	170	183	196	209	235	353	470	588
	4.50	136	148	160	173	185	197	222	333	444	555
	4.75	129	140	152	164	175	187	210	316	421	526
	5.00	122	133	144	156	167	178	200	300	400	500
	5.25	116	127	138	148	159	169	190	286	381	476
	5.50	111	121	131	141	151	162	182	273	364	454
	5.75	106	116	126	135	145	155	174	261	348	435
	6.00	102	111	120	130	139	148	167	250	333	417
	6.25	98	107	116	124	133	142	160	240	320	400
	6.50	94	103	111	120	128	137	154	231	308	385
	6.75	91	99	107	115	123	132	148	222	296	370
	7.00	87	95	103	111	119	127	143	214	286	357
	7.25	84	92	100	107	115	123	138	207	276	345
	7.50	81	89	96	104	111	118	133	200	267	333
	7.75	79	86	93	100	107	115	129	193	258	322
	8.00	76	83	90	97	104	111	125	187	250	312
	8.25	74	81	88	94	101	108	121	182	242	303
	8.50	72	78	85	91	98	105	118	176	235	294
	8.75	70	76	83	89	95	102	114	171	229	286
	9.00	68	74	80	86	93	99	111	167	222	278
	9.25	66	72	78	84	90	96	108	162	216	270
	9.50	64	70	76	82	88	94	105	158	210	263
	9.75	63	68	74	80	85	91	103	154	205	256
	10.00	61	67	72	78	83	89	100	150	200	250

$$\frac{\text{Size (Yards)} \times 1{,}000}{\text{MILS}} = \text{Distance (Yards)}$$

$$\frac{\text{Size (Inches)} \times 27.77}{\text{MILS}} = \text{Distance (Yards)}$$

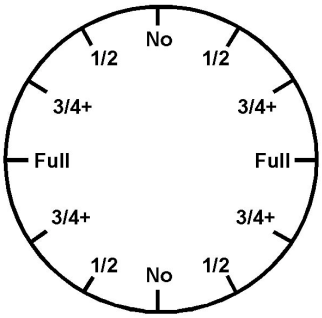
WIND CONSTANTS
.308 (7.62mm), 155 Grain

RELATIVE ELEVATION (FEET) \ RANGE	100	200	300	400	500	600	700	800	900	1,000
10,000	22	21.5	21.75	21	20.5	20.25	19.75	19.25	18.75	18
9,000	21.5	21.25	20.75	20.5	20	19.5	19	18.5	18	17.25
8,000	20.75	20.5	20	19.75	19.25	18.75	18.25	17.5	17	16.5
7,000	20.25	19.75	19.25	19	18.5	18	17.25	16.75	16.25	15.75
6,000	19.5	19	18.75	18.25	17.75	17.25	16.5	16	15.5	14.75
5,000	18.75	18.5	18	17.5	17	16.5	15.75	15	14.75	14
4,000	18.25	17.75	17.25	16.75	16.25	15.75	15	14.5	14	13.5
3,000	17.5	17	16.5	16	15.5	14.75	14.25	13.75	13.25	12.75
2,000	16.75	16.5	15.75	15.25	14.75	14.25	13.75	13	12.5	12
1,000	16.25	15.75	15	14.5	14	13.5	13	12.5	11.75	11.5
0	15.5	15	14.5	14	13.5	12.75	12.25	11.75	11.5	11

$$\frac{\text{RANGE/100 x VELOCITY (mph)}}{\text{CONSTANT}} = \text{MOA Correction}$$

Wind corrections are made INTO the wind.

Wind Value Clock



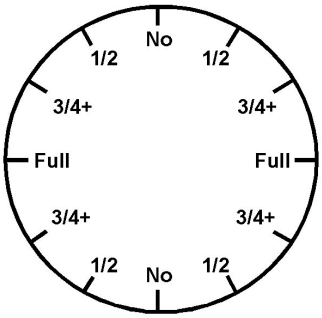
WIND CONSTANTS
.308 (7.62mm), 168 Grain

RELATIVE ELEVATION (FEET) \ RANGE	100	200	300	400	500	600	700	800	900	1,000
10,000	19.5	19	18.75	18	17.75	17.25	16.75	16.25	15.75	15.25
9,000	19	18.5	18	17.5	17	16.5	16	15.75	15	14.75
8,000	18.25	17.75	17.25	16.75	16.5	16	15.5	15	14.5	14
7,000	17.75	17	16.5	16	15.75	15	14.75	14.25	13.75	13.75
6,000	17	16.5	16	15.5	15	14.5	14	13.75	13.25	13.25
5,000	16.25	15.75	15.25	14.75	14.5	13.75	13.5	13.25	13	12.5
4,000	15.5	15	14.5	14	13.75	13.5	13.25	13	12.25	12
3,000	15	14.5	14	13.75	13.25	13	12.5	12	11.5	11
2,000	14.25	13.75	13.5	13.25	13	12.5	12	11.25	11	10.75
1,000	13.75	13.5	13.25	12.75	12.25	11.75	11	10.75	10.5	10
0	13.25	13	12.5	12	11.5	11	10.5	10.25	10	9.75

$$\frac{\text{RANGE/100 x VELOCITY (mph)}}{\text{CONSTANT}} = \text{MOA Correction}$$

Wind corrections are made INTO the wind.

Wind Value Clock



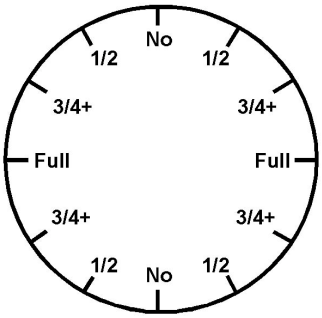
WIND CONSTANTS
.223 (5.56mm), 68-70 Grain

RELATIVE ELEVATION (FEET) \ RANGE	100	200	300	400	500	600	700	800	900	1,000
10,000	16.75	15.5	16	15.5	15	14.5	14	13.5	13	12.25
9,000	16.25	15.75	15.5	15	14.5	14	13.5	12.75	12.25	11.5
8,000	15.75	15.25	14.75	14.5	13.75	13.25	12.75	12.25	11.5	10.75
7,000	15	14.75	14.25	13.75	13.25	12.75	12.25	11.5	10.75	10
6,000	14.5	14	13.75	13.25	12.75	12	11.5	10.75	10	9.5
5,000	14	13.5	13	12.5	12	11.5	10.75	10.25	9.5	8.75
4,000	13.5	13	12.5	12	11.5	10.75	10.25	9.5	8.75	8
3,000	13	12.5	12	11.5	10.75	10.25	9.5	8.75	8	7
2,000	12.5	12	11.5	10.75	10.25	9.75	9	8	7.25	6.75
1,000	12	11.25	10.75	10.25	9.75	9	8.25	7.5	6.75	6
0	11.5	10.75	10.25	9.75	9	8.25	7.75	7	6.5	6

$$\frac{\text{RANGE/100 x VELOCITY (mph)}}{\text{CONSTANT}} = \text{MOA Correction}$$

Wind corrections are made INTO the wind.

Wind Value Clock



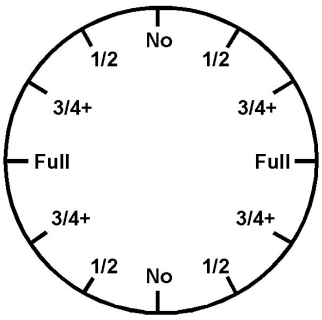
WIND CONSTANTS
.223 (5.56mm), 52-60 Grain

RELATIVE ELEVATION (FEET) \ RANGE	50	100	150	200	250	300	350	400	450	500	550	600
10,000	11.5	11.25	11	10.75	10.5	10.25	10	9.75	9.5	9.25	9	8.75
9,000	11	10.75	10.5	10.25	10	9.75	9.5	9.25	9	8.75	8.5	8.5
8,000	10.5	10.25	10	9.75	9.5	9.25	9	8.75	8.75	8.5	8.25	8
7,000	10.25	10	9.5	9.25	9	8.75	8.75	8.5	8.25	8	7.75	7.75
6,000	9.75	9.5	9.25	8.75	8.75	8.5	8.25	8	7.75	7.5	7.25	7.25
5,000	9.25	9	8.75	8.5	8.25	8	7.75	7.5	7.25	7	7	6.75
4,000	8.75	8.5	8.25	8	7.75	7.5	7.25	7	7	6.75	6.5	6.5
3,000	8.25	8	7.75	7.5	7.25	7	6.75	6.75	6.5	6.25	6.25	6
2,000	7.75	7.5	7.25	7	6.75	6.75	6.5	6.25	6	5.75	5.75	5.75
1,000	7.25	7	6.75	6.5	6.25	6.25	6	5.75	5.75	5.5	5.25	5.25
0	6.5	6.5	6.75	6	5.75	5.75	5.5	5.25	5.25	5	5	4.75

$$\frac{\text{RANGE/100 x VELOCITY (mph)}}{\text{CONSTANT}} = \text{MOA Correction}$$

Wind corrections are made INTO the wind.

Wind Value Clock



BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, Sea Level, 29.53 in/Hg, 30º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2497	2325	0.7	-1.1	-0.3	0.2	0.4
100	**2396**	**2142**	**2.7**	**0.0**	**0.0**	**0.8**	**0.8**
150	2298	1969	6.3	-1.4	-0.9	1.9	1.2
200	2202	1808	11.5	-4.4	-2.1	3.5	1.7
250	2108	1657	18.5	-9.2	-3.5	5.6	2.1
300	2012	1510	27.5	-15.9	-5.1	8.3	2.6
350	1918	1372	38.6	-24.8	-6.8	11.6	3.2
400	1827	1245	52.1	-36.1	-8.6	15.5	3.7
450	1739	1127	68.1	-49.9	-10.6	20.2	4.3
500	1653	1020	87.1	-66.7	-12.7	25.6	4.9
550	1570	920	109.2	-86.7	-15.0	31.8	5.5
600	1489	827	134.9	-110.1	-17.5	38.9	6.2
650	1411	743	164.5	-137.5	-20.2	47.0	6.9
700	1339	669	198.5	-169.3	-23.1	56.1	7.6
750	1272	603	237.3	-205.9	-26.2	66.2	8.4
800	1210	546	281.5	-247.8	-29.6	77.3	9.2
850	1155	498	331.6	-295.8	-33.2	89.5	10.0
900	1107	457	388.2	-250.2	-37.2	102.7	10.9
950	1065	423	451.9	-411.7	-41.4	116.9	11.7
1,000	1030	396	523.3	-480.9	-45.9	131.8	12.6

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, Sea Level, 29.53 in/Hg, 60º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2502	2335	0.7	-0.2	-0.3	0.2	0.4
100	**2406**	**2159**	**2.7**	**0.0**	**0.0**	**0.8**	**0.8**
150	2312	1994	6.3	-1.3	-0.9	1.8	1.2
200	2220	1839	11.4	-4.3	-2.1	3.3	1.6
250	2130	1693	18.4	-9.1	-3.5	5.3	2.0
300	2040	1552	27.2	-15.7	-5.0	7.8	2.5
350	1950	1418	38.2	-24.4	-6.7	10.9	3.0
400	1862	1293	51.4	-35.5	-8.5	14.6	3.5
450	1777	1178	67.1	-49.0	-10.4	19.0	4.0
500	1695	1072	85.6	-65.3	-12.5	24.0	4.6
550	1616	975	107.1	-84.6	-14.7	29.8	5.2
600	1538	882	132.0	-107.2	-17.1	36.4	5.8
650	1463	798	160.5	-133.6	-19.6	43.9	6.4
700	1392	723	193.1	-163.9	-22.4	52.2	7.1
750	1326	656	230.1	-198.8	-25.3	61.5	7.8
800	1265	597	272.2	-238.6	-28.5	71.7	8.6
850	1210	546	319.6	-283.8	-31.9	82.9	9.3
900	1161	503	373.0	-335.0	-35.5	95.1	10.1
950	1118	466	432.8	-392.6	-39.5	108.1	10.9
1,000	1080	435	499.6	-457.2	-43.7	122.0	11.6

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, Sea Level, 29.53 in/Hg, 90º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2507	2344	0.7	-0.2	-0.3	0.2	0.4
100	**2416**	**2177**	**2.7**	**0.0**	**0.0**	**0.8**	**0.7**
150	2326	2019	6.2	-1.3	-0.8	1.7	1.1
200	2239	1869	11.4	-4.3	-2.0	3.2	1.5
250	2153	1729	18.2	-8.9	-3.4	5.0	1.9
300	2068	1595	27.0	-15.5	-4.9	7.4	2.3
350	1982	1465	37.8	-24.1	-6.6	10.3	2.8
400	1898	1344	50.8	-34.9	-8.3	13.7	3.3
450	1817	1231	66.2	-48.1	-10.2	17.8	3.8
500	1738	1127	84.2	-63.9	-12.2	22.5	4.3
550	1662	1030	105.1	-82.6	-14.3	27.9	4.8
600	1589	941	129.2	-104.5	-16.6	34.0	5.4
650	1516	857	156.7	-129.8	-19.1	40.8	6.0
700	1447	781	188.0	-158.9	-21.7	48.5	6.6
750	1382	712	223.4	-192.1	-24.5	57.0	7.3
800	1322	652	263.4	-229.9	-27.4	66.4	7.9
850	1266	598	308.4	-272.7	-30.6	76.7	8.6
900	1216	552	358.8	-320.9	-34.0	87.8	9.3
950	1172	512	415.1	-375.0	-37.7	99.8	10.0
1,000	1133	479	477.7	-435.4	-41.6	112.6	10.7

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, 2,000 Feet, 29.53 in/Hg, 30º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2505	2341	0.7	-0.2	-0.3	0.2	0.4
100	**2412**	**2171**	**2.7**	**0.0**	**0.0**	**0.8**	**0.7**
150	2322	2010	6.2	-1.3	-0.8	1.8	1.1
200	2233	1859	11.4	-4.3	-2.0	3.2	1.5
250	2146	1717	18.3	-9.0	-3.4	5.1	2.0
300	2059	1580	27.1	-27.1	-4.9	7.5	2.4
350	1971	1449	37.9	-37.9	-6.6	10.5	2.9
400	1886	1326	51.0	-51.0	-8.4	14.0	3.3
450	1803	1212	66.5	-66.5	-10.3	18.2	3.9
500	1722	1106	84.7	-84.7	-12.3	23.0	4.4
550	1644	1008	1058	-105.8	-14.5	28.6	5.0
600	1567	916	130.1	-130.1	-16.8	34.9	5.5
650	1491	830	158.0	-158.0	-19.3	41.9	6.2
700	1420	752	189.8	-189.8	-21.9	50.0	6.8
750	1351	681	225.9	-225.9	-24.8	58.9	7.5
800	1288	618	266.8	-266.8	-27.8	68.7	8.2
850	1228	563	312.8	-312.8	-31.1	79.6	8.9
900	1174	514	364.7	-364.7	-34.7	91.4	9.7
950	1125	472	422.9	-422.9	-38.5	104.3	10.5
1,000	1082	437	488.0	-487.9	-42.6	118.1	11.3

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, 2,000 Feet, 29.53 in/Hg, 60º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2509	2349	0.7	-0.2	-0.3	0.2	0.4
100	**2421**	**2186**	**2.7**	**0.0**	**0.0**	**0.7**	**0.7**
150	2334	2031	6.2	-1.3	-0.8	1.7	1.1
200	2248	1886	11.3	-4.2	-2.0	3.1	1.5
250	2165	1748	18.2	-8.9	-3.4	4.9	1.9
300	2082	1617	26.9	-15.4	-4.9	7.1	2.3
350	1998	1489	37.5	-23.9	-6.5	9.9	2.7
400	1916	1369	50.4	-34.5	-8.2	13.3	3.2
450	1836	1257	65.7	-47.6	-10.1	17.2	3.6
500	1758	1153	83.5	-63.2	-12.1	21.7	4.1
550	1683	1056	104.1	-81.6	-14.2	29.9	4.7
600	1610	966	127.8	-103.1	-16.4	32.8	5.2
650	1537	881	154.9	-127.0	-18.9	39.5	5.8
700	1467	802	185.6	-156.5	-21.4	46.9	6.4
750	1400	731	220.4	-189.1	-24.1	55.2	7.0
800	1338	667	259.6	-226.1	-27.0	64.3	7.7
850	1279	610	303.7	-268.0	-30.1	74.4	8.3
900	1225	60	353.1	-315.2	-33.4	85.3	9.0
950	1176	516	408.2	-368.2	-37.0	97.2	9.8
1,000	1132	478	469.7	-427.5	-40.8	109.9	10.5

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, 2,000 Feet, 29.53 in/Hg, 90º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2514	2357	0.7	-0.2	-0.3	0.2	0.3
100	2429	2201	2.7	0.0	0.0	0.7	0.7
150	2346	2053	6.2	-1.3	-0.8	1.6	1.0
200	2265	1913	11.3	-4.2	-2.0	2.9	1.4
250	2185	1780	1801	-8.8	-3.3	4.6	1.8
300	2106	1655	26.6	-15.2	-4.8	6.8	2.2
350	2026	1531	37.2	-23.5	-6.4	9.4	2.6
400	1947	1414	49.9	-34.0	-8.1	12.5	3.0
450	1870	1305	64.9	-46.8	-9.9	16.2	3.4
500	1795	1202	82.3	-62.1	-11.8	20.5	3.9
550	1723	1107	102.5	-80.0	-13.9	25.3	4.4
600	1652	1018	125.5	-100.9	-16.1	30.8	4.9
650	1584	936	151.8	-125.0	-18.4	367.0	5.4
700	1516	857	181.5	-152.5	-20.8	43.9	6.0
750	1451	785	215.0	-183.8	-23.4	51.5	6.6
800	1390	720	252.7	-219.2	-26.2	60.0	7.2
850	1332	662	294.8	-259.2	-29.1	69.2	7.8
900	1279	910	341.8	-304.0	-32.3	79.3	8.4
950	1229	564	394.2	-354.2	-35.6	90.2	9.1
1,000	1185	523	452.3	-410.1	-39.2	102.0	9.7

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, 5,000 Feet, 29.53 in/Hg, 30º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2516	2361	0.7	-0.2	-0.3	0.2	0.3
100	**2434**	**2209**	**2.7**	**0.0**	**0.0**	**0.7**	**0.6**
150	2353	2066	6.2	-1.3	-0.8	1.6	1.0
200	2274	1929	11.2	-4.1	-2.0	2.8	1.3
250	2197	1800	18.0	-8.7	-3.3	4.5	1.7
300	2121	1677	26.5	-15.1	-4.8	6.5	2.1
350	2043	1557	37.0	-23.4	-6.4	9.1	2.5
400	1966	1442	49.6	-33.7	-8.0	12.1	2.9
450	1891	1333	64.4	-46.3	-9.8	15.6	3.3
500	1817	1232	81.6	-61.4	-11.7	19.7	3.8
550	1745	1136	101.5	-79.0	-13.7	24.4	4.2
600	1675	1047	124.2	-99.6	-15.8	29.7	4.7
650	1607	964	150.0	-123.2	-18.1	35.6	5.2
700	1539	883	179.2	-150.2	-20.5	42.2	5.8
750	1473	809	212.0	-180.8	-23.0	49.6	6.3
800	1409	740	248.9	-215.5	-25.7	57.8	6.9
850	1348	678	290.1	-254.5	-28.6	66.8	7.5
900	1290	621	336.1	-298.4	-31.7	76.7	8.1
950	1236	570	387.4	-347.4	-34.9	87.4	8.8
1,000	1185	524	444.3	-402.1	-38.4	99.1	9.5

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, 5,000 Feet, 29.53 in/Hg, 60º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2519	2367	0.7	-0.2	-0.3	0.2	0.3
100	**2440**	**2221**	**2.7**	**0.0**	**0.0**	**0.6**	**0.6**
150	2363	2082	6.2	-1.3	-0.8	1.5	0.9
200	2286	1950	11.2	-4.1	-2.0	2.7	1.3
250	2212	1824	17.9	-8.7	-3.3	4.3	1.6
300	2138	1705	26.4	-14.9	-4.7	6.3	2.0
350	2064	1589	36.7	-23.1	-6.3	8.7	2.4
400	1990	1477	49.2	-33.3	-8.0	11.5	2.8
450	1917	1370	63.8	-45.8	-9.7	14.9	3.2
500	1845	1270	80.8	-60.5	-11.6	18.8	3.6
550	1776	1176	100.3	-77.9	-13.5	23.2	4.0
600	1708	1088	122.6	-98.0	-15.6	28.2	4.5
650	1642	1006	147.8	-121.0	-17.8	33.8	5.0
700	1577	928	176.3	-147.3	-20.1	40.1	5.5
750	1512	853	208.3	-177.1	-22.5	47.0	6.0
800	1450	784	244.1	-210.7	-25.1	54.7	6.5
850	1391	721	284.0	-248.4	-27.9	63.2	7.1
900	1334	664	328.4	-290.7	-30.8	72.4	7.7
950	1281	612	377.7	-337.8	-33.9	82.5	8.3
1,000	1230	565	432.3	-390.2	-37.3	93.3	8.9

BALLISTIC TABLE

.308 Win. Sierra 168 Gr. HPBT MatchKing

100 Yard Zero, 5,000 Feet, 29.53 in/Hg, 90º F

BALLISTIC COEFFICIENTS: 0.462, 0.447, 0.405
HEIGHT OF SIGHT: 1.7”
MUZZLE VELOCITY: 2600 fps

RANGE (Yards)	VELOCITY (fps)	ENERGY (ft/lbs)	DROP (In)	PATH (In)	PATH (MOA)	10 MPH X-WIND (In)	10 MPH X-WIND (MOA)
50	2523	2374	0.7	-0.2	-0.3	0.1	0.3
100	**2447**	**2234**	**2.7**	**0.0**	**0.0**	**0.6**	**0.6**
150	2373	2100	6.1	-1.3	-0.8	1.4	0.9
200	2299	1972	11.2	-4.1	-2.0	2.6	1.2
250	2228	1851	17.8	-8.6	-3.3	4.1	1.6
300	2157	1735	26.2	-14.8	-4.7	6.0	1.9
350	2087	1624	36.5	-22.9	-6.2	8.3	2.3
400	2015	1514	48.8	-33.0	-7.9	11.0	2.6
450	1945	1410	63.2	-45.2	-9.6	14.2	3.0
500	1876	1312	79.9	-59.7	-11.4	17.8	3.4
550	1809	1220	99.1	-76.7	-13.3	22.0	3.8
600	1743	1133	120.9	-96.3	-15.3	26.7	4.3
650	1679	1052	145.6	-118.8	-17.5	32.0	4.7
700	1617	975	172.3	-144.4	-19.7	37.9	5.2
750	1555	902	204.4	-173.3	-22.1	44.4	5.6
800	1495	833	239.1	-205.8	-24.6	51.5	6.1
850	1437	770	277.7	-242.2	-27.2	59.4	6.7
900	1381	711	320.5	-282.8	-30.0	68.0	7.2
950	1329	658	367.9	-328.0	-33.0	77.4	7.8
1,000	1279	610	420.1	-378.1	-36.1	87.5	8.3

WIND CORRECTION TABLE

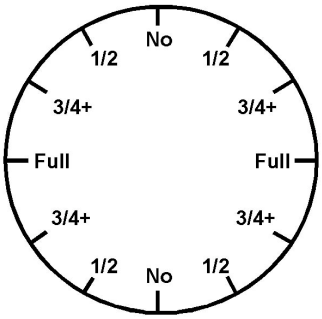
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 0 FEET

WIND VELOCITY (MPH) RANGE	100	200	300	400	500	600	700	800	900	1,000
3	0.23	0.46	0.72	1.00	1.30	1.64	2.00	2.34	2.70	3.08
4	0.30	0.62	0.96	1.33	1.74	2.18	2.67	3.12	3.60	4.10
5	0.38	0.77	1.20	1.67	2.17	2.73	3.33	3.90	4.50	5.13
6	0.45	0.92	1.44	2.00	2.61	3.27	4.00	4.68	5.40	6.15
7	0.53	1.08	1.68	2.33	3.04	3.82	4.67	5.46	6.30	7.18
8	0.60	1.23	1.92	2.67	3.48	4.36	5.33	6.24	7.20	8.21
9	0.68	1.38	2.16	3.00	3.91	4.91	6.00	7.02	8.10	9.23
10	0.75	1.54	2.40	3.33	4.35	5.45	6.67	7.80	9.00	10.26
11	0.83	1.69	2.64	3.67	4.78	6.00	7.33	8.59	9.90	11.28
12	0.91	1.85	2.88	4.00	5.22	6.55	8.00	9.37	10.80	12.31
13	0.98	2.00	3.12	4.33	5.65	7.09	8.67	10.15	11.70	13.33
14	1.06	2.15	3.36	4.67	6.09	7.64	9.33	10.93	12.60	14.36
15	1.13	2.31	3.60	5.00	6.52	8.18	10.00	11.71	13.50	15.38
16	1.21	2.46	3.84	5.33	6.96	8.73	10.67	12.49	14.40	16.41
17	1.28	2.62	4.08	5.67	7.39	9.27	11.33	13.27	15.30	17.44
18	1.36	2.77	4.32	6.00	7.83	9.82	12.00	14.05	16.20	18.46
19	1.43	2.92	4.56	6.33	8.26	10.36	12.67	14.83	17.10	19.49
20	1.51	3.08	4.80	6.67	8.70	10.91	13.33	15.61	18.00	20.51

Wind Value Clock



WIND CORRECTION TABLE

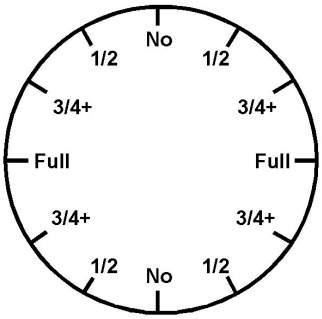
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 1,000 FEET

WIND VELOCITY (MPH)	RANGE	100	200	300	400	500	600	700	800	900	1,000
	3	0.22	0.44	0.68	0.94	1.22	1.53	1.91	2.23	2.57	3.00
	4	0.29	0.59	0.91	1.25	1.63	2.04	2.55	2.98	3.43	4.00
	5	0.36	0.74	1.13	1.57	2.04	2.55	3.18	3.72	4.29	5.00
	6	0.44	0.89	1.36	1.88	2.45	3.06	3.82	4.47	5.14	6.00
	7	0.51	1.04	1.58	2.20	2.86	3.57	4.45	5.21	6.00	7.00
	8	0.58	1.19	1.81	2.51	3.27	4.09	5.09	5.95	6.86	8.00
	9	0.65	1.33	2.04	2.82	3.67	4.60	5.73	6.70	7.71	9.00
	10	0.73	1.48	2.26	3.14	4.08	5.11	6.36	7.44	8.57	10.00
	11	0.80	1.63	2.49	3.45	4.49	5.62	7.00	8.19	9.43	11.00
	12	0.87	1.78	2.72	3.76	4.90	6.13	7.64	8.93	10.29	12.00
	13	0.95	1.93	2.94	4.08	5.31	6.64	8.27	9.67	11.14	13.00
	14	1.02	2.07	3.17	4.39	5.71	7.15	8.91	10.42	12.00	14.00
	15	1.09	2.22	3.40	4.71	6.12	7.66	9.55	11.16	12.86	15.00
	16	1.16	2.37	3.62	5.02	6.53	8.17	10.18	11.91	13.71	16.00
	17	1.24	2.52	3.85	5.33	6.94	8.68	10.82	12.65	14.57	17.00
	18	1.31	2.67	4.08	5.65	7.35	9.19	11.45	13.40	15.43	18.00
	19	1.38	2.81	4.30	5.96	7.76	9.70	12.09	14.14	16.29	19.00
	20	1.45	2.96	4.53	6.27	8.16	10.21	12.73	14.88	17.14	20.00

Wind Value Clock



WIND CORRECTION TABLE

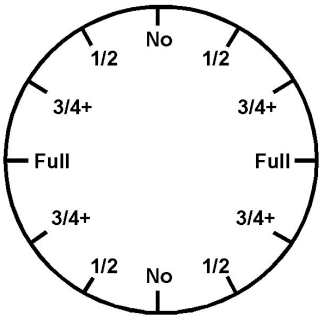
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 2,000 FEET

WIND VELOCITY (MPH) RANGE	100	200	300	400	500	600	700	800	900	1,000
3	0.21	0.44	0.67	0.91	1.15	1.44	1.75	2.13	2.45	2.79
4	0.28	0.58	0.89	1.21	1.54	1.92	2.33	2.84	3.27	3.72
5	0.35	0.73	1.11	1.51	1.92	2.40	2.92	3.56	4.09	4.65
6	0.42	0.87	1.33	1.81	2.31	2.88	3.50	4.27	4.91	5.58
7	0.49	1.02	1.56	2.11	2.69	3.36	4.08	4.98	5.73	6.51
8	0.56	1.16	1.78	2.42	3.08	3.84	4.67	5.69	6.55	7.44
9	0.63	1.31	2.00	2.72	3.46	4.32	5.25	6.40	7.36	8.37
10	0.70	1.45	2.22	3.02	3.85	4.80	5.83	7.11	8.18	9.30
11	0.77	1.60	2.44	3.32	4.23	5.28	6.42	7.82	9.00	10.23
12	0.84	1.75	2.67	3.62	4.62	5.76	7.00	8.53	9.82	11.16
13	0.91	1.89	2.89	3.92	5.00	6.24	7.58	9.24	10.64	12.09
14	0.98	2.04	3.11	4.23	5.38	6.72	8.17	9.96	11.45	13.02
15	1.05	2.18	3.33	4.53	5.77	7.20	8.75	10.67	12.27	13.95
16	1.12	2.33	3.56	4.83	6.15	7.68	9.33	11.38	13.09	14.88
17	1.19	2.47	3.78	5.13	6.54	8.16	9.92	12.09	13.91	15.81
18	1.26	2.62	4.00	5.43	6.92	8.64	10.50	12.80	14.73	16.74
19	1.33	2.76	4.22	5.74	7.31	9.12	11.08	13.51	15.55	17.67
20	1.40	2.91	4.44	6.04	7.69	9.60	11.67	14.22	16.36	18.60

Wind Value Clock



WIND CORRECTION TABLE

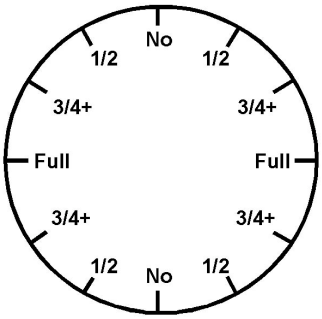
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 3,000 FEET

WIND VELOCITY (MPH)	RANGE 100	200	300	400	500	600	700	800	900	1,000
3	0.20	0.41	0.64	0.87	1.13	1.38	1.68	2.00	2.35	2.73
4	0.27	0.55	0.86	1.16	1.51	1.85	2.24	2.67	3.13	3.64
5	0.33	0.69	1.07	1.45	1.89	2.31	2.80	3.33	3.91	4.55
6	0.40	0.83	1.29	1.75	2.26	2.77	3.36	4.00	4.70	5.45
7	0.47	0.97	1.50	2.04	2.64	3.23	3.92	4.67	5.48	6.36
8	0.53	1.10	1.71	2.33	3.02	3.69	4.48	5.33	6.26	7.27
9	0.60	1.24	1.93	2.62	3.40	4.15	5.04	6.00	7.04	8.18
10	0.67	1.38	2.14	2.91	3.77	4.62	5.60	6.67	7.83	9.09
11	0.73	1.52	2.36	3.20	4.15	5.08	6.16	7.33	8.61	10.00
12	0.80	1.66	2.57	3.49	4.53	5.54	6.72	8.00	9.39	10.91
13	0.87	1.79	2.79	3.78	4.91	6.00	7.28	8.67	10.17	11.82
14	0.93	1.93	3.00	4.07	5.28	6.46	7.84	9.33	10.96	12.73
15	1.00	2.07	3.21	4.36	5.66	6.92	8.40	10.00	11.74	13.64
16	1.07	2.21	3.43	4.65	6.04	7.38	8.96	10.67	12.52	14.55
17	1.13	2.34	3.64	4.95	6.42	7.85	9.52	11.33	13.30	15.45
18	1.20	2.48	3.86	5.24	6.79	8.31	10.08	12.00	14.09	16.36
19	1.27	2.62	4.07	5.53	7.17	8.77	10.64	12.67	14.87	17.27
20	1.33	2.76	4.29	5.82	7.55	9.23	11.20	13.33	15.65	18.18

Wind Value Clock



WIND CORRECTION TABLE

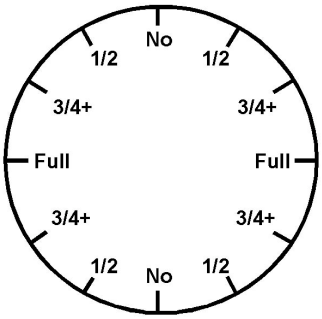
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 4,000 FEET

WIND VELOCITY (MPH) RANGE	100	200	300	400	500	600	700	800	900	1,000
3	0.19	0.40	0.62	0.86	1.09	1.33	1.58	1.85	2.20	2.50
4	0.26	0.53	0.83	1.14	1.45	1.78	2.11	2.46	2.94	3.33
5	0.32	0.67	1.03	1.43	1.82	2.22	2.64	3.08	3.67	4.17
6	0.39	0.80	1.24	1.71	2.18	2.67	3.17	3.69	4.41	5.00
7	0.45	0.93	1.45	2.00	2.55	3.11	3.70	4.31	5.14	5.83
8	0.52	1.07	1.66	2.29	2.91	3.56	4.23	4.92	5.88	6.67
9	0.58	1.20	1.86	2.57	3.27	4.00	4.75	5.54	6.61	7.50
10	0.65	1.33	2.07	2.86	3.64	4.44	5.28	6.15	7.35	8.33
11	0.71	1.47	2.28	3.14	4.00	4.89	5.81	6.77	8.08	9.17
12	0.77	1.60	2.48	3.43	4.36	5.33	6.34	7.38	8.82	10.00
13	0.84	1.73	2.69	3.71	4.73	5.78	6.87	8.00	9.55	10.83
14	0.90	1.87	2.90	4.00	5.09	6.22	7.40	8.62	10.29	11.67
15	0.97	2.00	3.10	4.29	5.45	6.67	7.92	9.23	11.02	12.50
16	1.03	2.13	3.31	4.57	5.82	7.11	8.45	9.85	11.76	13.33
17	1.10	2.27	3.52	4.86	6.18	7.56	8.98	10.46	12.49	14.17
18	1.16	2.40	3.72	5.14	6.55	8.00	9.51	11.08	13.22	15.00
19	1.23	2.53	3.93	5.43	6.91	8.44	10.04	11.69	13.96	15.83
20	1.29	2.67	4.14	5.71	7.27	8.89	10.57	12.31	14.69	16.67

Wind Value Clock



WIND CORRECTION TABLE

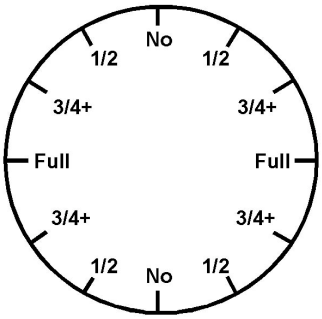
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 5,000 FEET

WIND VELOCITY (MPH)	RANGE	100	200	300	400	500	600	700	800	900	1,000
	3	0.18	0.38	0.59	0.81	1.03	1.31	1.56	1.81	2.08	2.40
	4	0.25	0.51	0.79	1.08	1.38	1.75	2.07	2.42	2.77	3.20
	5	0.31	0.63	0.98	1.36	1.72	2.18	2.59	3.02	3.46	4.00
	6	0.37	0.76	1.18	1.63	2.07	2.62	3.11	3.62	4.15	4.80
	7	0.43	0.89	1.38	1.90	2.41	3.05	3.63	4.23	4.85	5.60
	8	0.49	1.02	1.57	2.17	2.76	3.49	4.15	4.83	5.54	6.40
	9	0.55	1.14	1.77	2.44	3.10	3.93	4.67	5.43	6.23	7.20
	10	0.62	1.27	1.97	2.71	3.45	4.36	5.19	6.04	6.92	8.00
	11	0.68	1.40	2.16	2.98	3.79	4.80	5.70	6.64	7.62	8.80
	12	0.74	1.52	2.36	3.25	4.14	5.24	6.22	7.25	8.31	9.60
	13	0.80	1.65	2.56	3.53	4.48	5.67	6.74	7.85	9.00	10.40
	14	0.86	1.78	2.75	3.80	4.83	6.11	7.26	8.45	9.69	11.20
	15	0.92	1.90	2.95	4.07	5.17	6.55	7.78	9.06	10.38	12.00
	16	0.98	2.03	3.15	4.34	5.52	6.98	8.30	9.66	11.08	12.80
	17	1.05	2.16	3.34	4.61	5.86	7.42	8.81	10.26	11.77	13.60
	18	1.11	2.29	3.54	4.88	6.21	7.85	9.33	10.87	12.46	14.40
	19	1.17	2.41	3.74	5.15	6.55	8.29	9.85	11.47	13.15	15.20
	20	1.23	2.54	3.93	5.42	6.90	8.73	10.37	12.08	13.85	16.00

Wind Value Clock



WIND CORRECTION TABLE

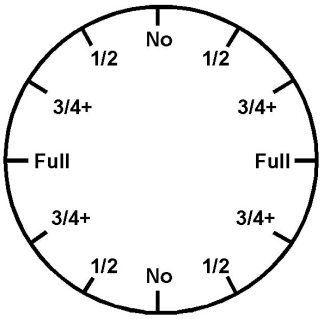
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 6,000 FEET

WIND VELOCITY (MPH)	RANGE	100	200	300	400	500	600	700	800	900	1,000
	3	0.18	0.36	0.56	0.77	1.00	1.24	1.50	1.75	2.04	2.26
	4	0.24	0.48	0.75	1.03	1.33	1.66	2.00	2.33	2.72	3.02
	5	0.29	0.61	0.94	1.29	1.67	2.07	2.50	2.91	3.40	3.77
	6	0.35	0.73	1.13	1.55	2.00	2.48	3.00	3.49	4.08	4.53
	7	0.41	0.85	1.31	1.81	2.33	2.90	3.50	4.07	4.75	5.28
	8	0.47	0.97	1.50	2.06	2.67	3.31	4.00	4.65	5.43	6.04
	9	0.53	1.09	1.69	2.32	3.00	3.72	4.50	5.24	6.11	6.79
	10	0.59	1.21	1.88	2.58	3.33	4.14	5.00	5.82	6.79	7.55
	11	0.65	1.33	2.06	2.84	3.67	4.55	5.50	6.40	7.47	8.30
	12	0.71	1.45	2.25	3.10	4.00	4.97	6.00	6.98	8.15	9.06
	13	0.76	1.58	2.44	3.35	4.33	5.38	6.50	7.56	8.83	9.81
	14	0.82	1.70	2.63	3.61	4.67	5.79	7.00	8.15	9.51	10.57
	15	0.88	1.82	2.81	3.87	5.00	6.21	7.50	8.73	10.19	11.32
	16	0.94	1.94	3.00	4.13	5.33	6.62	8.00	9.31	10.87	12.08
	17	1.00	2.06	3.19	4.39	5.67	7.03	8.50	9.89	11.55	12.83
	18	1.06	2.18	3.38	4.65	6.00	7.45	9.00	10.47	12.23	13.58
	19	1.12	2.30	3.56	4.90	6.33	7.86	9.50	11.05	12.91	14.34
	20	1.18	2.42	3.75	5.16	6.67	8.28	10.00	11.64	13.58	15.09

Wind Value Clock



WIND CORRECTION TABLE

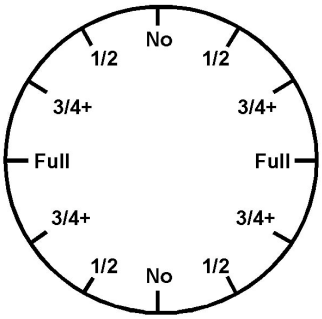
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 7,000 FEET

WIND VELOCITY (MPH)	RANGE	100	200	300	400	500	600	700	800	900	1,000
	3	0.17	0.35	0.55	0.75	0.95	1.20	1.42	1.68	1.96	2.18
	4	0.23	0.47	0.73	1.00	1.27	1.60	1.90	2.25	2.62	2.91
	5	0.28	0.59	0.91	1.25	1.59	2.00	2.37	2.81	3.27	3.64
	6	0.34	0.71	1.09	1.50	1.90	2.40	2.85	3.37	3.93	4.36
	7	0.39	0.82	1.27	1.75	2.22	2.80	3.32	3.93	4.58	5.09
	8	0.45	0.94	1.45	2.00	2.54	3.20	3.80	4.49	5.24	5.82
	9	0.51	1.06	1.64	2.25	2.86	3.60	4.27	5.05	5.89	6.55
	10	0.56	1.18	1.82	2.50	3.17	4.00	4.75	5.61	6.55	7.27
	11	0.62	1.29	2.00	2.75	3.49	4.40	5.22	6.18	7.20	8.00
	12	0.68	1.41	2.18	3.00	3.81	4.80	5.69	6.74	7.85	8.73
	13	0.73	1.53	2.36	3.25	4.13	5.20	6.17	7.30	8.51	9.45
	14	0.79	1.65	2.55	3.50	4.44	5.60	6.64	7.86	9.16	10.18
	15	0.85	1.76	2.73	3.75	4.76	6.00	7.12	8.42	9.82	10.91
	16	0.90	1.88	2.91	4.00	5.08	6.40	7.59	8.98	10.47	11.64
	17	0.96	2.00	3.09	4.25	5.40	6.80	8.07	9.54	11.13	12.36
	18	1.01	2.12	3.27	4.50	5.71	7.20	8.54	10.11	11.78	13.09
	19	1.07	2.24	3.45	4.75	6.03	7.60	9.02	10.67	12.44	13.82
	20	1.13	2.35	3.75	5.00	6.35	8.00	9.49	11.23	13.09	14.55

Wind Value Clock



WIND CORRECTION TABLE

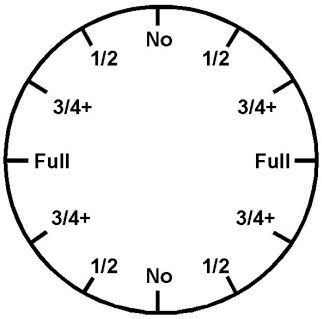
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 8,000 FEET

WIND VELOCITY (MPH)	RANGE 100	200	300	400	500	600	700	800	900	1,000
3	0.16	0.34	0.52	0.72	0.91	1.13	1.35	1.60	1.86	2.14
4	0.22	0.45	0.70	0.96	1.21	1.50	1.81	2.13	2.48	2.86
5	0.27	0.56	0.87	1.19	1.52	1.88	2.26	2.67	3.10	3.57
6	0.33	0.68	1.04	1.43	1.82	2.25	2.71	3.20	3.72	4.29
7	0.38	0.79	1.22	1.67	2.12	2.63	3.16	3.73	4.34	5.00
8	0.44	0.90	1.39	1.91	2.42	3.00	3.61	4.27	4.97	5.71
9	0.49	1.01	1.57	2.15	2.73	3.38	4.06	4.80	5.59	6.43
10	0.55	1.13	1.74	2.39	3.03	3.75	4.52	5.33	6.21	7.14
11	0.60	1.24	1.91	2.63	3.33	4.13	4.97	5.87	6.83	7.86
12	0.66	1.35	2.09	2.87	3.64	4.50	5.42	6.40	7.45	8.57
13	0.71	1.46	2.26	3.10	3.94	4.88	5.87	6.93	8.07	9.29
14	0.77	1.58	2.43	3.34	4.24	5.25	6.32	7.47	8.69	10.00
15	0.82	1.69	2.61	3.58	4.55	5.63	6.77	8.00	9.31	10.71
16	0.88	1.80	2.78	3.82	4.85	6.00	7.23	8.53	9.93	11.43
17	0.93	1.92	2.96	4.06	5.15	6.38	7.68	9.07	10.55	12.14
18	0.99	2.03	3.13	4.30	5.45	6.75	8.13	9.60	11.17	12.86
19	1.04	2.14	3.30	4.54	5.76	7.13	8.58	10.13	11.79	13.57
20	1.10	2.25	3.75	4.78	6.06	7.50	9.03	10.67	12.41	14.29

Wind Value Clock



WIND CORRECTION TABLE

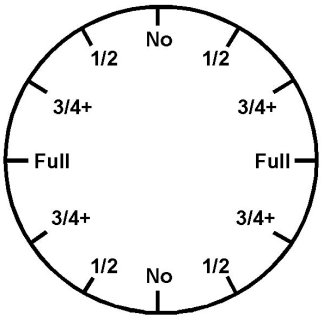
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 9,000 FEET

WIND VELOCITY (MPH)	RANGE	100	200	300	400	500	600	700	800	900	1,000
	3	0.16	0.32	0.50	0.69	0.88	1.09	1.31	1.52	1.80	2.03
	4	0.21	0.43	0.67	0.91	1.18	1.45	1.75	2.03	2.40	2.71
	5	0.26	0.54	0.83	1.14	1.47	1.82	2.19	2.54	3.00	3.39
	6	0.32	0.65	1.00	1.37	1.76	2.18	2.63	3.05	3.60	4.07
	7	0.37	0.76	1.17	1.60	2.06	2.55	3.06	3.56	4.20	4.75
	8	0.42	0.86	1.33	1.83	2.35	2.91	3.50	4.06	4.80	5.42
	9	0.47	0.97	1.50	2.06	2.65	3.27	3.94	4.57	5.40	6.10
	10	0.53	1.08	1.67	2.29	2.94	3.64	4.38	5.08	6.00	6.78
	11	0.58	1.19	1.83	2.51	3.24	4.00	4.81	5.59	6.60	7.46
	12	0.63	1.30	2.00	2.74	3.53	4.36	5.25	6.10	7.20	8.14
	13	0.68	1.41	2.17	2.97	3.82	4.73	5.69	6.60	7.80	8.81
	14	0.74	1.51	2.33	3.20	4.12	5.09	6.13	7.11	8.40	9.49
	15	0.79	1.62	2.50	3.43	4.41	5.45	6.56	7.62	9.00	10.17
	16	0.84	1.73	2.67	3.66	4.71	5.82	7.00	8.13	9.60	10.85
	17	0.89	1.84	2.83	3.89	5.00	6.18	7.44	8.63	10.20	11.53
	18	0.95	1.95	3.00	4.11	5.29	6.55	7.88	9.14	10.80	12.20
	19	1.00	2.05	3.17	4.34	5.59	6.91	8.31	9.65	11.40	12.88
	20	1.05	2.16	3.75	4.57	5.88	7.27	8.75	10.16	12.00	13.56

Wind Value Clock



WIND CORRECTION TABLE

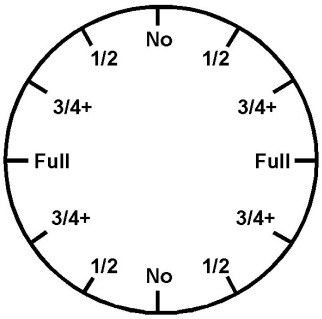
.308 (7.62MM), 168 Grain

Using Wind Formula

RE 10,000 FEET

WIND VELOCITY (MPH)	RANGE	100	200	300	400	500	600	700	800	900	1,000
	3	0.15	0.32	0.48	0.67	0.85	1.04	1.25	1.48	1.71	1.97
	4	0.21	0.42	0.64	0.89	1.13	1.39	1.67	1.97	2.29	2.62
	5	0.26	0.53	0.80	1.11	1.41	1.74	2.09	2.46	2.86	3.28
	6	0.31	0.63	0.96	1.33	1.69	2.09	2.51	2.95	3.43	3.93
	7	0.36	0.74	1.12	1.56	1.97	2.43	2.93	3.45	4.00	4.59
	8	0.41	0.84	1.28	1.78	2.25	2.78	3.34	3.94	4.57	5.25
	9	0.46	0.95	1.44	2.00	2.54	3.13	3.76	4.43	5.14	5.90
	10	0.51	1.05	1.60	2.22	2.82	3.48	4.18	4.92	5.71	6.56
	11	0.56	1.16	1.76	2.44	3.10	3.83	4.60	5.42	6.29	7.21
	12	0.62	1.26	1.92	2.67	3.38	4.17	5.01	5.91	6.86	7.87
	13	0.67	1.37	2.08	2.89	3.66	4.52	5.43	6.40	7.43	8.52
	14	0.72	1.47	2.24	3.11	3.94	4.87	5.85	6.89	8.00	9.18
	15	0.77	1.58	2.40	3.33	4.23	5.22	6.27	7.38	8.57	9.84
	16	0.82	1.68	2.56	3.56	4.51	5.57	6.69	7.88	9.14	10.49
	17	0.87	1.79	2.72	3.78	4.79	5.91	7.10	8.37	9.71	11.15
	18	0.92	1.89	2.88	4.00	5.07	6.26	7.52	8.86	10.29	11.80
	19	0.97	2.00	3.04	4.22	5.35	6.61	7.94	9.35	10.86	12.46
	20	1.03	2.11	3.75	4.44	5.63	6.96	8.36	9.85	11.43	13.11

Wind Value Clock



1 MIL EQUIVALENCY TABLE
50-1,000 Yards, 50-1,000 Meters

YARDS	INCHES
25	0.9
50	1.8
100	3.6
150	5.4
200	7.2
250	9.0
300	10.8
350	12.6
400	14.4
450	16.2
500	18.0
550	19.8
600	21.6
650	23.4
700	25.2
750	27.0
800	28.8
850	30.6
900	32.4
950	34.2
1,000	36.0

METERS	INCHES
25	1.0
50	2.0
100	3.9
150	5.9
200	7.9
250	9.8
300	11.8
350	13.8
400	15.7
450	17.7
500	19.7
550	21.7
600	23.6
650	25.6
700	27.6
750	29.5
800	31.5
850	33.5
900	35.4
950	37.4
1,000	39.4

RANGING MEASUREMENTS

OBJECT	LENGTH	WIDTH
Axe		35”
Basketball	9.75”	9.75”
Beer/Soda Can, 12 oz.	4.75”	2.5”
Cigarette Pack, Regulars	3.5”	2.25”
Coffee Mug, Average	3.75”	3.25”
Cup, Small Styrofoam	3.5”	
Door Knob, Circular	2.25”	2.25”
Door, Standard Household	84”	
Door, Standard Household - Bottom to Doorknob	36”	
Fence Post, Cyclone		2.75”
Fire Hydrant	31”	
Ford Expedition, 2000	56”	
Head (Average Human)	9”	
IPSC Target, Standard	29.5”	18”
License Plate, Motor Vehicle	6”	12”
Light Bulb, Standard Household	4.25”	2.5”
Lock Mechanism, Auto Door	1.25”	1.25”
M-4, Stock Collapsed	29.8”	
M-4, Stock Extended	33”	
MGM Steel Silhouette Target	26”	17.75”
Milk Jug, 1gal.	9.5”	
Nalgene Bottle, 32oz.	8.25”	3.5”
Notebook Paper	11”	8.5”
Padlock, Body		1.75”
Pistol Slide, 1911 Government	8.5”	
Pistol Slide, 1911 Officer’s	6.25”	
Pistol Slide, Berretta	7.5”	
Pistol Slide, Glock Compact	6.85”	
Pistol Slide, Glock Full Size	7.32”	
Pistol Slide, Glock Sub-Compact	6.29”	
Pistol Slide, HK USP Compact	6.81”	
Rake, Steel Tooth Garden	65”	16”
Shovel, Long Handle		37.25”
Shovel, Spade Handheld		37.25”
Sidewalk, Average		61”
Snuff Can	1”	2.25”
Soda Bottle, 3 Liter	13”	5”
Stop Sign	30”	30”

Telephone, Public	21.5”	8.5”
Telephone, Receiver	8”	
Tire Rim, Auto	14.5-16”	14.5-16”

NOTE: Colored text represents objects used specifically during training.

TRAINING EXERCISES

Sonoma County Stress-Fire C-2

KIM Game (Keep In Memory) C-3

Balloon Shoot C-4

On-Command Mover C-5

Snap Shooting C-6

Run-N-Gun C-7

The Stalk C-8

Hide Sites C-9

Scope Shakeout C-10

Flag Ranging Course C-11

Green-Light C12

SONOMA COUNTY STRESS-FIRE

Purpose: To elevate and sustain heart rate through mild exercise, to load rifle and manipulate bolt while experiencing mild stress, and to practice controlled breathing to settle heart rate.

Materials: Face Photo Target

1. From the 100-yard line, shooter jogs to the 125-yard line carrying an empty rifle and returns to the 100-yard line, performs 15 pushups, loads, and fires 2 rounds at training target from the prone position.

2. From the 100-yard line, shooter jogs to the 125-yard line with an empty rifle and returns to the 75-yard line where he loads and fires 2 rounds from the seated position.

3. From the 75-yard line, shooter jogs to the 100-yard line with an empty rifle and returns to the 50-yard line where he loads and fires 2 rounds from the kneeling position.

4. From the 50-yard line, shooter jogs to the 75-yard line with an empty rifle and returns to the 25-yard line where he loads and fires 2 rounds from the standing position.

5. At the 25-yard line, the shooter will load the 2 remaining rounds. First shot will be a "snap shot" from standing at the ready, and the second shot will be from standing to kneeling.

Standard: Rounds fired on the face target must be in the T-zone. Any round out of the T-zone is considered a miss.

Note: Shooters are limited to 20 seconds once they are in position to complete their 2 shots. The goal is to control respiration/heart rate. Shots are supposed to be taken quickly.

KIM GAME

Purpose: To test and exercise the memory skills of the PM/O.

Materials: 10-15 familiar objects, cover cloth, stopwatch, paper and pencil.

Several objects are placed on the ground or on a table and covered with a cloth. The PM/Os are assembled around the display and the cover cloth is removed. The PM/Os are then given one minute to study the objects. They are not allowed to speak to one another or to handle the objects. When the time limit has expired, the objects are covered again. The PM/Os are then required to perform some type of distracting activity (i.e. running a mile or building a hide site). Upon completing the task, the PM/Os are given 2-3 minutes to list the objects on their paper.

Standard: 80% of the items recalled correctly.

Note: The exercise can be made more challenging by shortening the amount of time the PM/Os are allowed to study the objects, or by using distractions during the observation portion of the exercise.

BALLOON SHOOT

Purpose: To engage a moving threat among moving hostages using colored balloons to simulate hostages and threats.

Materials: 8 inch colored helium balloons, moving target system or remote controlled car, tape or stapler.

Three helium balloons of different colors are attached to the moving target system or remote controlled car. The PM/Os are set up at a distance between 50 and 100 yards. An out-of-bounds maker or hide is set up at each end of the target path to limit the amount of time the PM/O has to track and shoot the target. With the target moving at a reasonable speed, the PM/O is given the color of balloon (threat) to engage. The PM/O must shoot the balloon without hitting the other two balloons (hostages).

Standard: Perform three consecutive threat eliminations with zero misses from 100 yards.

Note: The exercise can be varied by changing the shooting angle and shooting distance. Smaller balloons or longer distances can be used to make the exercise even more challenging.

The amount of difficulty should slowly be advanced to a level where failure is expected part of the time to emphasize the difficulty of this type of shot. The PM/O should leave this training exercise with a good understanding of his capabilities and limitations.

ON-COMMAND MOVER

Purpose: To engage a moving threat on command in order to time the incapacitation of a threat.

Materials: 8 inch colored helium balloons or a face targets, moving target system or remote controlled car, tape or stapler.

A face target or helium balloon is attached to the moving target system, or a balloon may be attached to a remote controlled car. The PM/O is set up at a distance between 50 and 100 yards. With the target moving at a reasonable speed, the PM/O is given the "Sierra Unit Up" signal. He will respond with "Sierra One Up" (or whatever number he is assigned). The controller will then say, "I have control, ready, fire!" When the PM/O hears the command to fire he will shoot the target. The PM/O will not shoot if he does not hear the word "fire," or if he is not ready or able to shoot.

Standard: Perform three consecutive threat eliminations with zero misses from 50 yards or farther. Shooting before the command is given or shooting too late after the command is given is considered failure.

SNAP SHOOTING

Purpose: To engage a threat that is exposed for only a brief moment. This exercise will test the PM/O's ability to engage targets of opportunity.

Materials: Face targets, 100-200 yard range with pivoting or pop-up target system.

The targets, both threats and non-threats, are exposed for 2-4 seconds. The PM/O must identify the threat and place and incapacitating shot (T-zone) on the threat target. The targets are exposed at random intervals with no cue to the PM/O as to when the target will appear.

Standard: All shots should be within the face T-zone.

RUN-N-GUN

Purpose: To test the PM/O's ability to perform under stress.

Materials: Face targets.

The PM/O must sprint 220 yards (1/8 mile) to the 100-yard firing line while in full uniform with pack and gear. Upon arriving at the firing line he will ground his gear, set up his mat and rifle, and perform 10 pushups. After completing the pushups, the PM/O will set up in the prone position and fire one shot at a face target.

Standard: Time limit to complete the exercise is four minutes. All shots should be within the face T-zone.

Note: This exercise may be used with other shooting positions, both supported and unsupported. When using less stable positions a silhouette target should be used, requiring the PM/O to shoot center mass instead of hear shots.

THE STALK

Purpose: To practice and perfect the skill of stealth movement.

Materials: Stopwatch, handheld radios, silhouette target, personal deployment gear.

A life size silhouette target is set up in an area with variable terrain. One or two spotters will stand guarding the target. Their job is to look for PM/Os moving in the area. If a PM/O is spotted, the spotter must talk the coordinator to within an arms reach of the PM/O.

The exercise begins by having the PM/O move from a location where he cannot be seen by the spotters. The PM/O's job is to move into a position where he could conceivably make a head shot on the target. He must do this within a prescribed time limit, which will depend on the distance and terrain to be covered. When the PM/O has reached his shooting position, he should perform a shooting solution and make any necessary dope changes on his rifle. Once he is prepared for the shot, the PM/O will fire one round at the head of the target, or stand up and announce that he is finished if the location does not allow for a live shot.

To rate the PM/O, the coordinator must look at the target from the PM/O's vantage through the rifle scope. The PM/O is judged on the suitability of his position and on the likelihood of making a successful shot. Environmental conditions such and wind and temperature, as well as slope angle and range should be checked and compared with the PM/O's shooting solution.

Standard: To pass the exercise, the PM/O must move into position undetected and fire (or simulate firing) one round at a head size target.

Note: Sending a PM/O out alone helps him to focus on individual skills. Sending PM/Os out in pairs helps them become comfortable with non-verbal communication and allows them to practice moving in pairs.

HIDE SITES

Purpose: To practice creating a hide site that will conceal the PM/O's forward operating position.

Materials: Stopwatch, unoccupied structure, personal deployment gear.

The PM/O is sent to a location to create a concealed position from which he can observe and engage a designated target. He is allowed to use only those items that he would normally carry or that can be found within the hide site area. The time limit should be set in minutes and should not be extravagantly long.

The PM/O is evaluated on how well he makes use of light contrast and on how inconspicuous is it appears from the target's viewpoint. Other factors that should be evaluated include the amount of protective cover the hide site offers, whether changing factors (i.e. rising or setting sun, passing car lights) will cause complications, and how much shelter from the elements the hide site provides.

Standard: The PM/O or PM/O Team must complete the hide site within the allotted time limit. The hide must be judged effective in the areas of cover, concealment, routes of ingress and egress, and sustainability.

SCOPE SHAKEOUT

Purpose: This exercise allows the PM/O to measure the angular adjustment of the optical sights for his particular weapon system.

Materials: General purpose target with 1" grid squares or smaller, calculator.

1. Zero the weapon at a range of 100 yards.

2. Adjust the windage knob to get a four MOA rise in the point of impact. Shoot a group of 3-5 shots and measure the distance from the center of the group to the bullseye.

NOTE: If there is any appreciable lateral movement then there is a problem with the scope, or the scope is a canted or not aligned properly.

3. Reset the scope to the 100-yard zero and shoot another group to make sure that the scope returns to the original point of impact.

4. Divide the measurement in inches between the first shot group and the 4 MOA shot group by four.

5. Divide the number derived in Step 4 by 1.047. This will give the exact amount of POI shift for each MOA dialed on the scope. (An exact MOA is 1.047 inches at 100 yards.)

6. Repeat Steps 1-5 for the down, left, and right adjustments to the scope.

NOTE: The windage and elevation adjustment gears in the scope may not move at the same rates.

Example: A 4 MOA vertical scope adjustment causes a shift in the POI of 4 5/8 inches. 4 5/8 inches (4.625) divided by 4 equals 1.156. 1.156 divided by 1.047 equals 1.104 inches. Therefore, every 1 MOA vertical adjustment shifts the POI by about 1.1 inches.

FLAG RANGING COURSE

Purpose: To allow the PM/O to practice estimating distances.

Materials: Laser range finder, 24 landscape marking flags, paper & pencils.

A target is set up in location with natural features. Landscape marking flags are numbered and set up randomly throughout the location. A sketch of the area is then made showing the target and the flags and listing the actual distance from each flag to the target. The PM/Os are then sent out individually to determine and record the range from each flag to the target.

Note: A familiar object such as a patrol vehicle, a life-size face target, or any object with known dimensions should be used so that the PM/O can practice ranging through his optical sight.

GREEN-LIGHT

Purpose: To test the PM/O's ability to stay focused on his target for an extended period of time.

Materials: Face target, watch.

A face target is placed 100 yards from the shooter. The shooter assumes a supported prone position and is instructed to aim in on his target, but to hold his fire until his boot is kicked. A period of about 15-20 minutes should be allowed to elapse before the PM/O is given a kick, signifying that he should take his shot. The PM/O should fire his shot within 1-2 seconds from the time he receives his kick.

Note: Twenty minutes is about the maximum amount of time the PM/O should be expected to remain on target without experiencing the negative effects of fatigue. The time limit for this drill may be extended to emphasize the need to rotate on and off the gun during extended overwatch.

FORMULAS & CONVERSIONS

MIL-SCALE RANGING

$$\frac{\text{Size of Target (Meters)} \times 1{,}000}{\text{Mils}} = \text{Distance (Meters)}$$

$$\frac{\text{Size of Target (Yards)} \times 1{,}000}{\text{Mils}} = \text{Distance (Yards)}$$

$$\frac{\text{Size of Target (Inches)} \times 25.4}{\text{Mils}} = \text{Distance (Meters)}$$

$$\frac{\text{Size of Target (Inches)} \times 27.77}{\text{Mils}} = \text{Distance (Yards)}$$

PLEX RANGING

$$\frac{\text{Length (Inches)} \times 104.72}{\text{MOA}} = \text{Distance (Yards)}$$

SIZE

$$\frac{\text{Mils} \times \text{Distance (Yards)}}{27.77} = \text{Size (Inches)}$$

$$\frac{\text{MOA} \times \text{Distance (Yards)}}{104.72} = \text{Size (Inches)}$$

RELATIVE ALTITUDE

$$\text{AE} + (29.53 - \text{Hg} \times 1{,}000) = \text{Relative Altitude}$$

WIND VELOCITY

$$\frac{\text{ANGLE}^{\circ}}{4} = \text{MPH}$$

WIND CORRECTION

$$\frac{\text{RANGE/100 } \mathbf{x} \text{ VELOCITY}}{\text{CONSTANT}} = \text{MOA correction}$$

SLOPE

Range (meters) **x** Cosine = CHD

SLOPE	5º	10º	15º	20º	25º	30º	35º	40º	45º
COSINE	.99	.98	.96	.94	.91	.87	.82	.77	.70

SLOPE	50º	55º	60º	65º	70º	75º	80º	85º	90º
COSINE	.64	.57	.50	.42	.34	.26	.17	.09	.00

Bullet Drop (MOA) **x** Sine = MOA Down Correction

SLOPE	5º	10º	15º	20º	25º	30º	35º	40º	45º
SINE	.01	.02	.04	.06	.09	.13	.18	.23	.30

SLOPE	50º	55º	60º	65º	70º	75º	80º	85º	90º
SINE	.36	.43	.50	.58	.66	.74	.83	.91	.00

TARGET LEADS

MPH **x** 1.4667 = FPS

Time of Flight (seconds) **x** Target Speed (fps) = Lead (feet)

Time of Flight (seconds) **x** Target Speed (fps) **x** 12 = Lead (inches)

$$\frac{\text{Lead in Inches} \div (\text{Range in Yards}/100)}{3.6} = \text{Mil Lead}$$

$$\frac{\text{Lead in Meters} \times 1{,}000}{\text{Range (meters)}} = \text{Mil Lead}$$

CONVERSIONS

$$\frac{\text{Inches} \div (\text{Range in Yards}/100)}{3.6} = \text{Mils}$$

$$\frac{\text{Inches} \div (\text{Range in Yards}/100)}{1.0472} = \text{MOA}$$

MOA **x** (Range in Yards/100) **x** 1.0472 = Inches

Mils **x** (Range in Yards/100) **x** 3.6 = Inches

MOA **x** 0.296 = Mils

Yards **x** 0.9144 = Meters

Meters / 0.9144 = Yards

MPH **x** 1.4667 = FPS

EQUIVALENTS

1 MOA = 1.0472 inches @ 100 yards

1 Mil = 3.59 inches @ 100 yards

TIPS OF THE TRADE

- A bolt-action rifle equipped with an internal magazine can be "speed-loaded" by turning the rifle upside down with the bolt closed, opening the magazine floorplate, dropping the rounds into the magazine well, and then closing the floorplate.

- Friction tape can be added to the gripping portions of a rifle to enhance control of the weapon when firing.

- When it is necessary to transport ammunition in a vehicle for callout purposes, stowing the ammunition in a cooler will help protect it from extreme heat or extreme cold, which can affect the powder burn rate.

- Adding a kisser button or a strip of hook and loop fasteners to the stock of the rifle will aid the shooter in obtaining a consistent stock weld.

- A quick fix for engaging man-sized targets at multiple ranges is to put the 300-yard zero on the rifle and use the mil-dots to engage at various ranges. For every hundred yards, the shooter holds one mil high or low (200 yards = 1 mil low, 100 yards = 2 mil low, 400 yards = 1 mil high, 500 yards = 2 mil high). This technique works well out to 500 yards.

- It is recommended that the shooter bottom out his windage and elevation adjustments in both directions and record the number of MOA from zero for each direction. The shooter can use this information to confirm by feel that his rifle is on zero.

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Los Angeles County Sheriffs Department, Special Enforcement Bureau SWAT

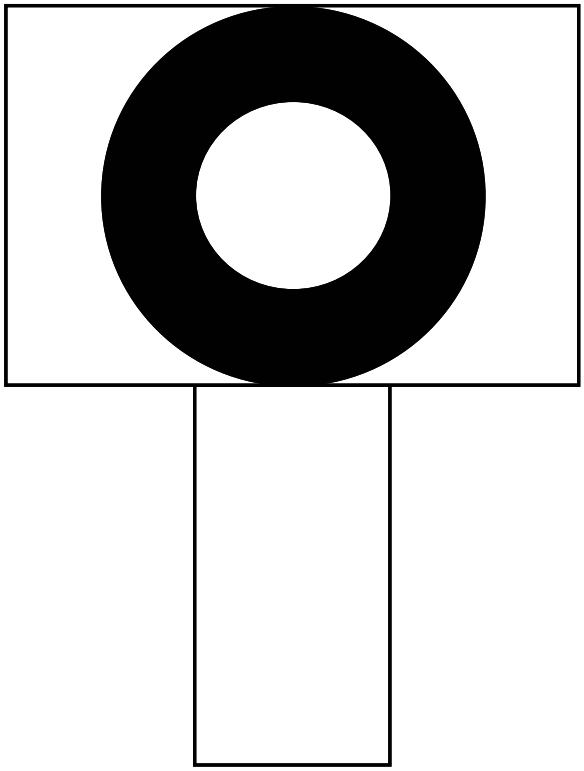
Michigan State Police, Emergency Support Team

San Antonio Police Department, SWAT

San Diego County Sheriffs Department, SWAT

ATTACHMENTS

PRECISION RIFLE COLD-BORE TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

Shooter	Date	Temp/Humid	Location/Altitude

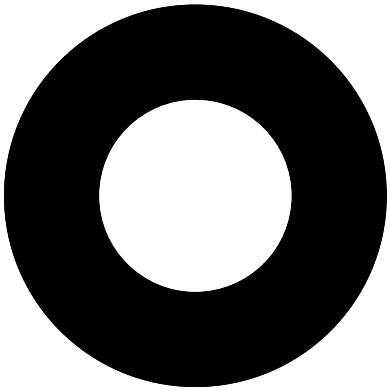
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 1/2004

Page Number _____

2" BULLSEYE TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

Shooter	Date	Temp/Humid	Location/Altitude

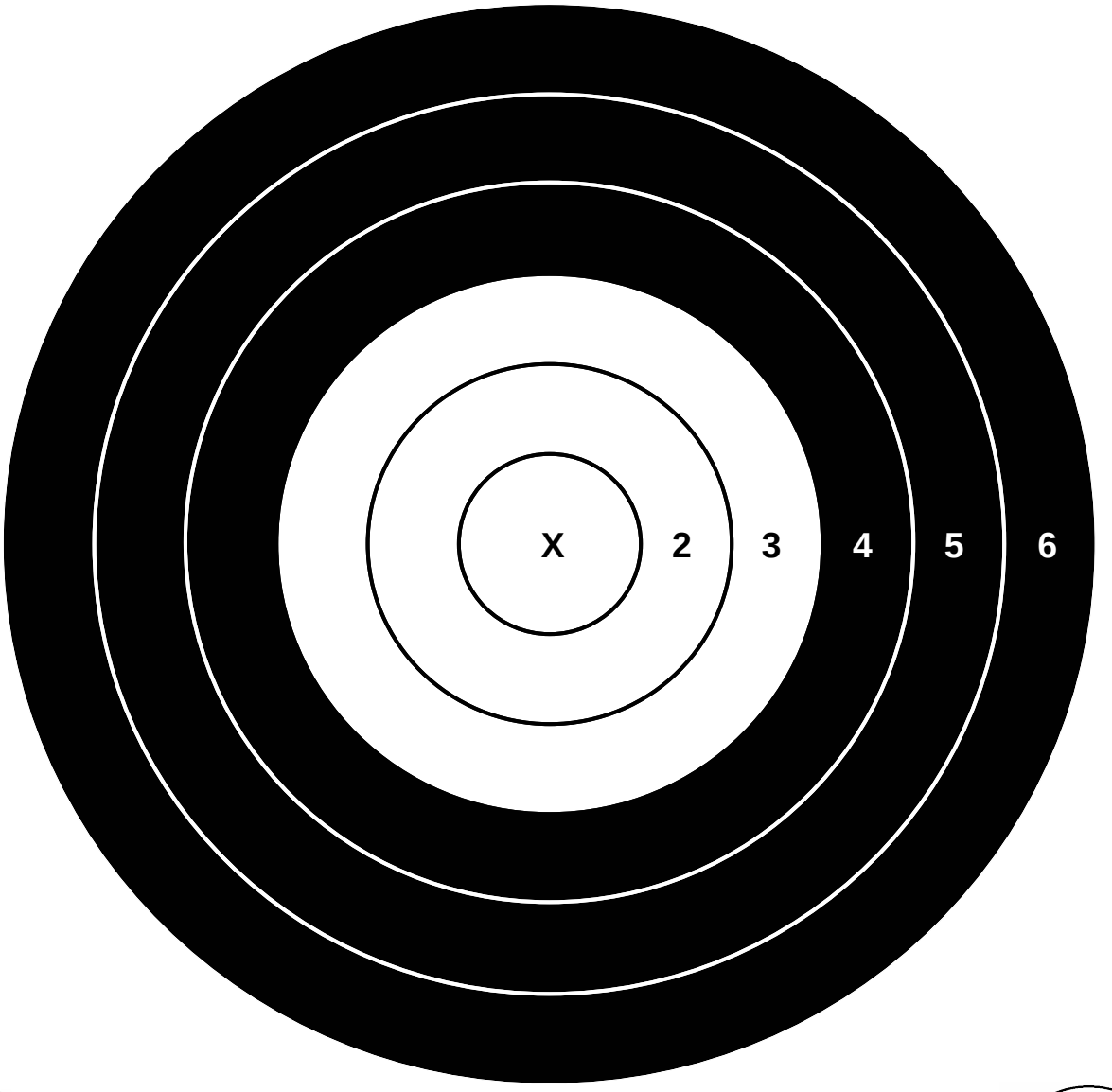
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 1/2004

Page Number _____

6" BULLSEYE TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

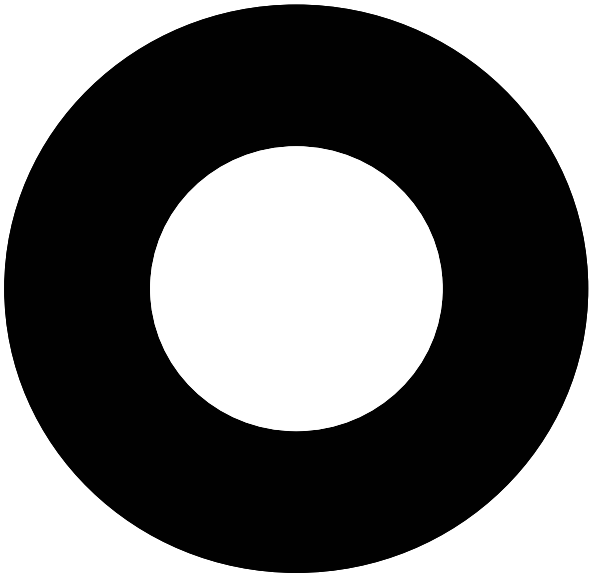
Shooter	Date	Temp/Humid	Location/Altitude	
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 1/2004

Page Number _____

3" BULLSEYE TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

Shooter	Date	Temp/Humid	Location/Altitude

Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 2/2004

Page Number _____

7 1/4" TARGET

U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

Shooter	Date	Temp/Humid	Location/Altitude

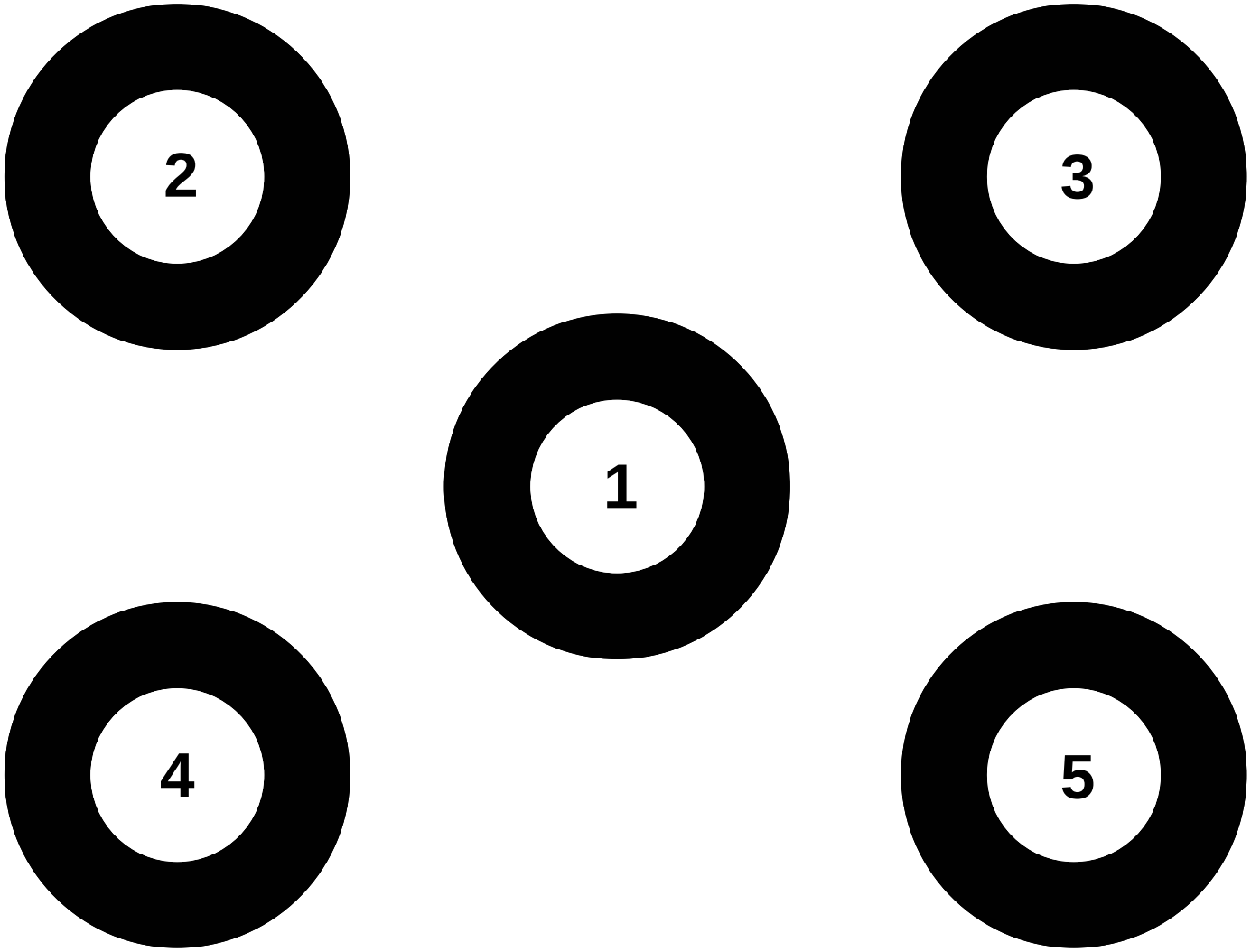
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 1/2004

Page Number _____

NUMBERED BULLSEYE TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

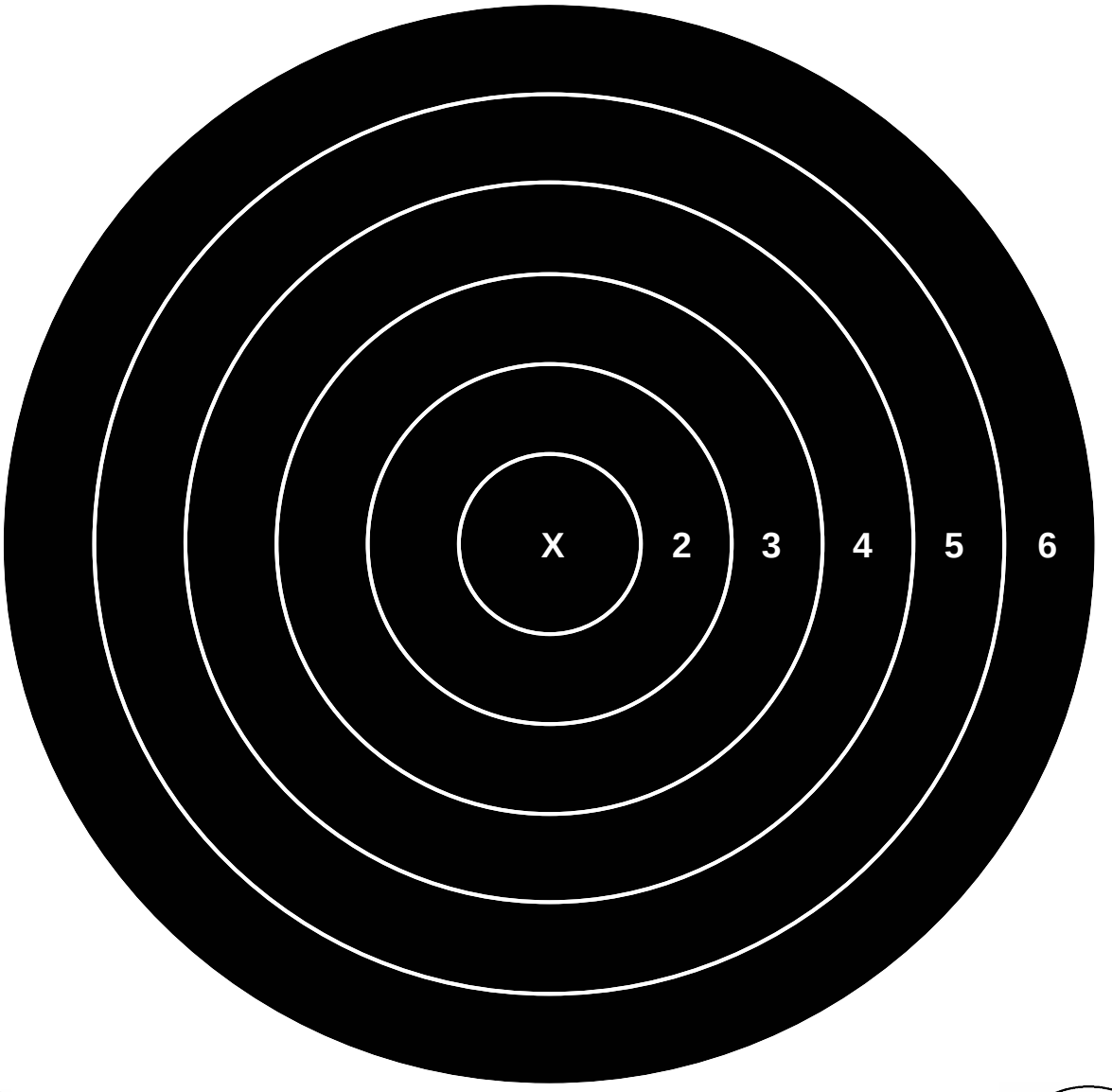
Shooter	Date	Temp/Humid	Location/Altitude	
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 1/2004

Page Number _____

6" BULLSEYE TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

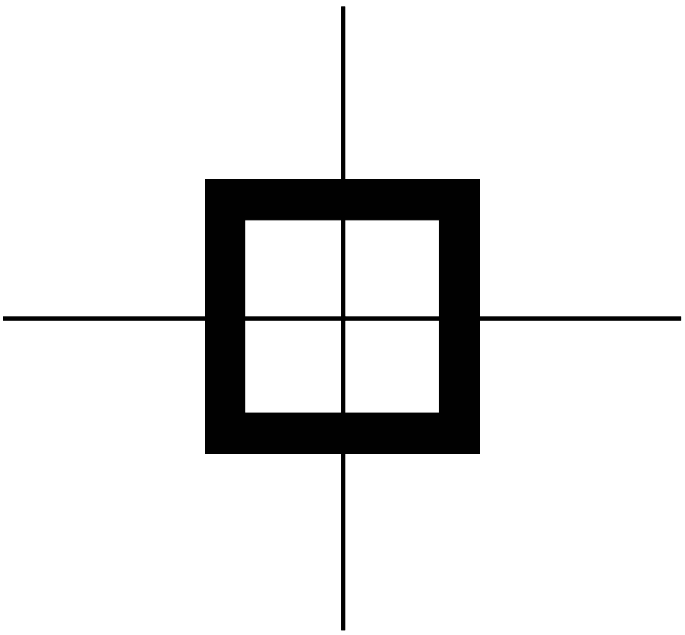
Shooter	Date	Temp/Humid	Location/Altitude	
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

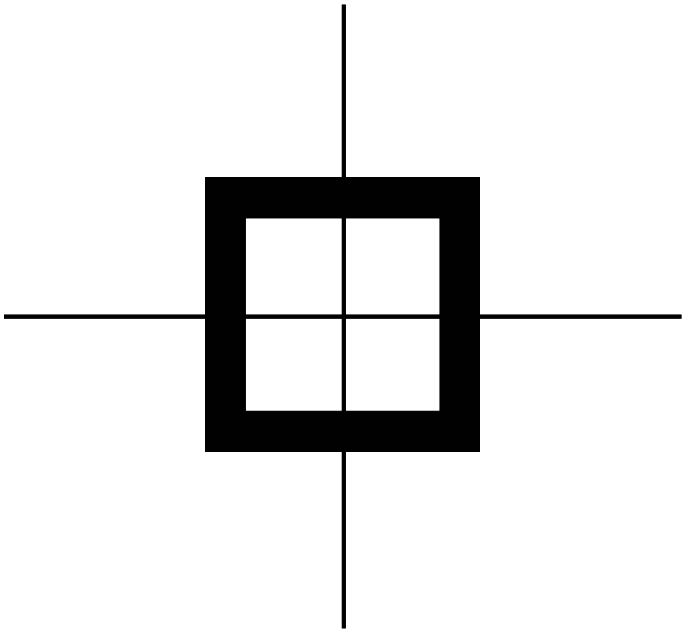
Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

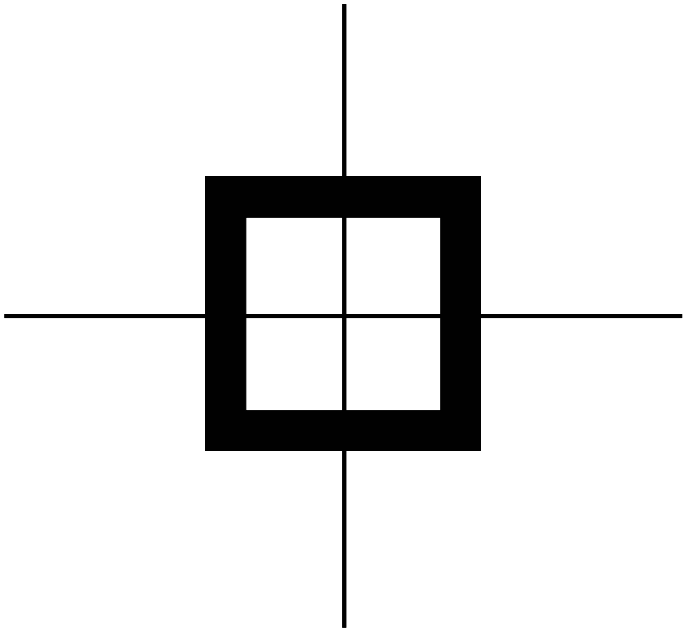
Revised: 1/2004

Page Number _____

1" CROSSHAIR INDICATOR







U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

Shooter	Date	Temp/Humid	Location/Altitude

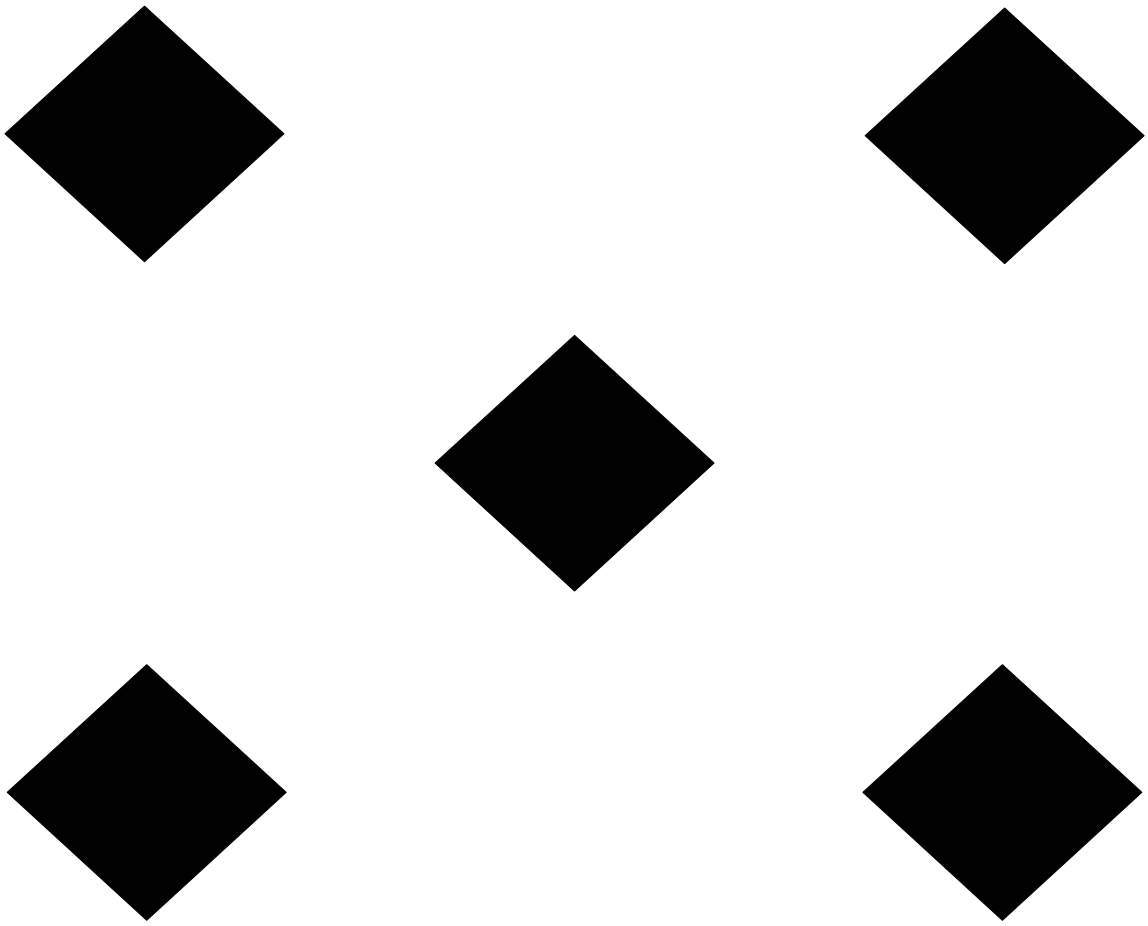
Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 1/2004

Page Number _____

1" DIAMONDS TARGET



U.S. DEPARTMENT OF HOMELAND SECURITY **U.S. BORDER PATROL**

Shooter	Date	Temp/Humid	Location/Altitude

Rifle Serial Number	Ammo Lot Number	Range	Shooting Position	Time

Sight Changes	Starting	Ending	Mirage	Light Direction	Wind Direction	Wind Speed
Elevation						Remarks
Windage						

Revised: 11/2004

Page Number _____

Name _____
Date _____
Rifle Serial # _____

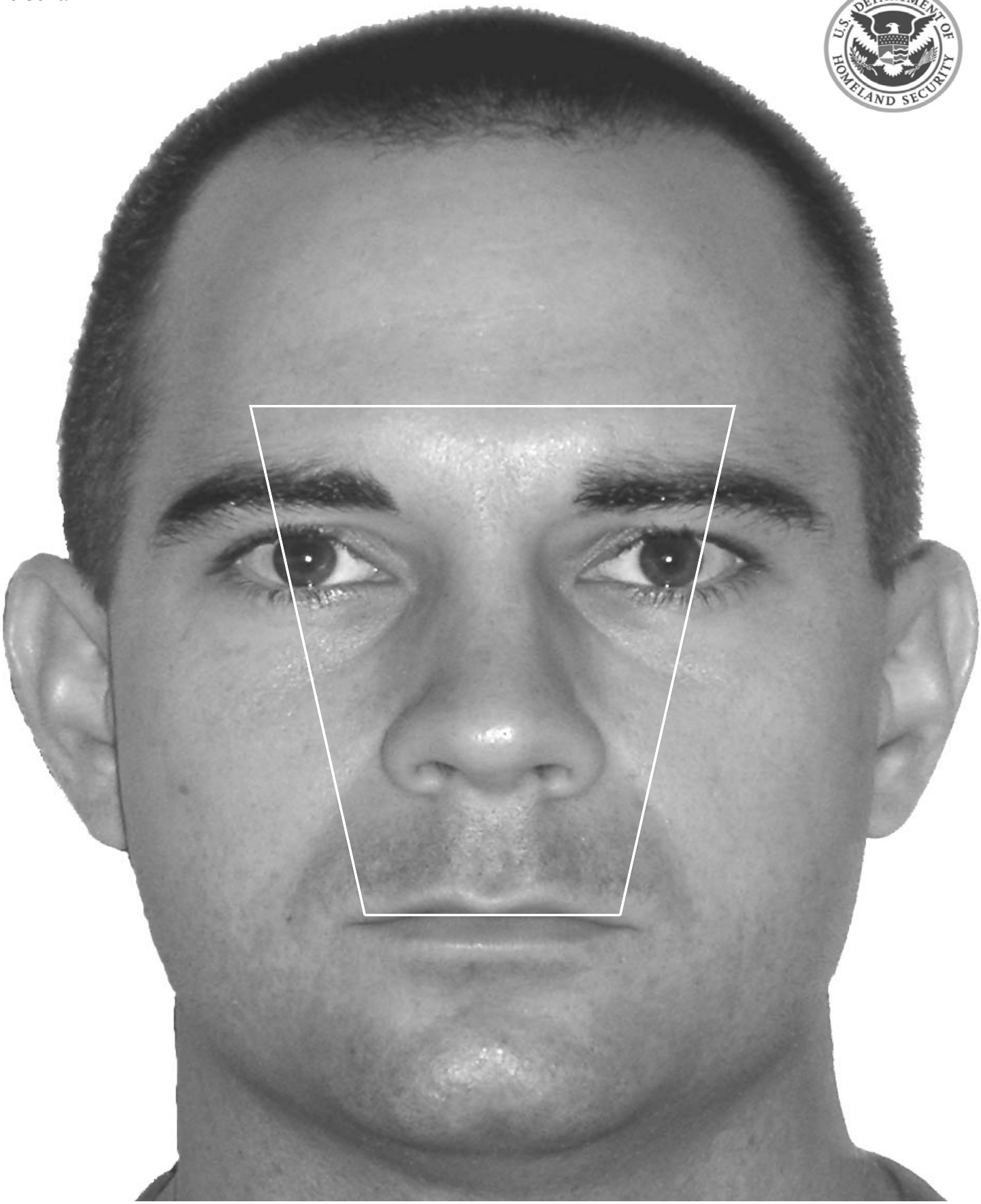
FACE 1 TARGET

Name _____
Date _____
Rifle Serial # _____

FACE 2 TARGET

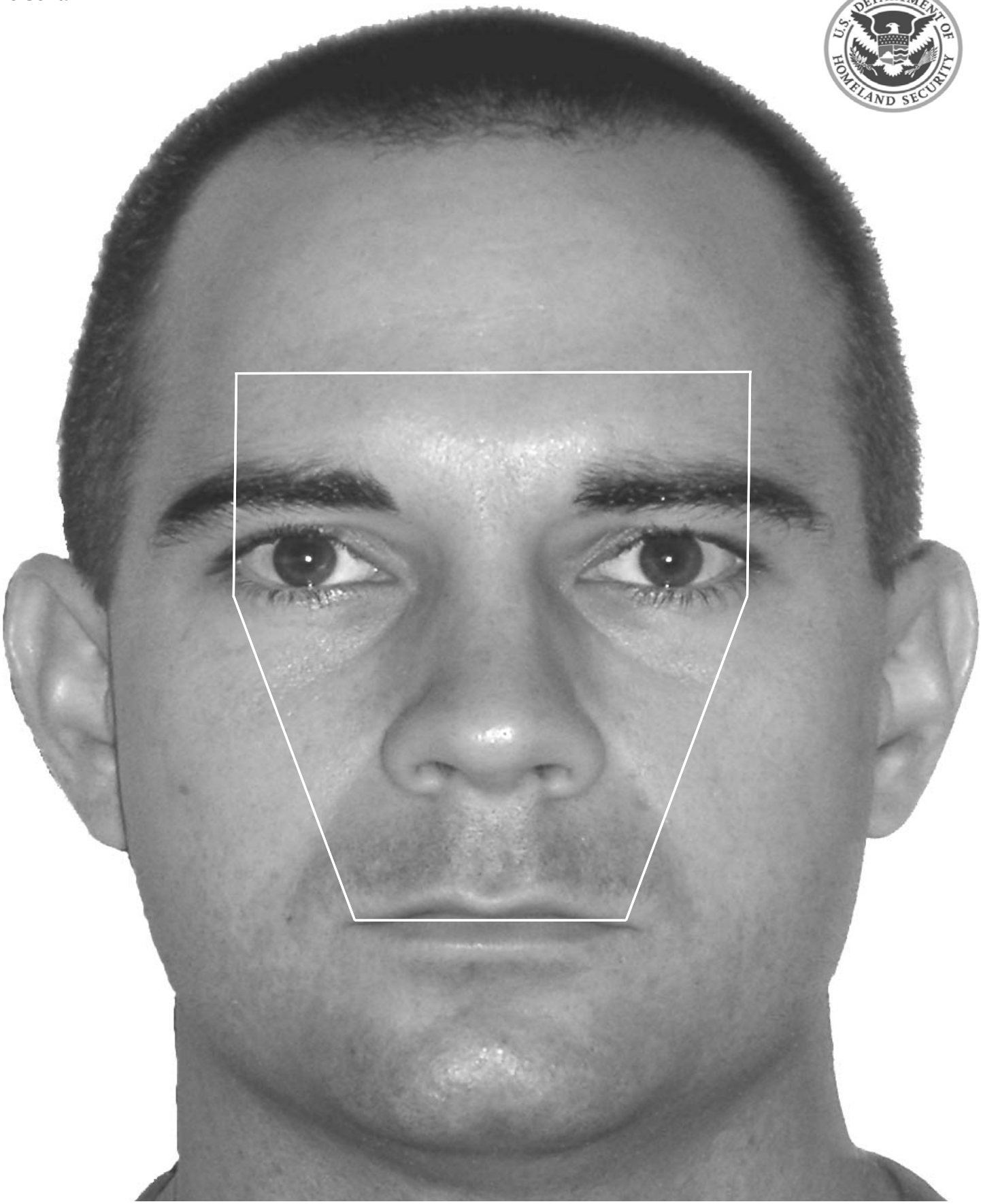
Name _____
Date _____
Rifle Serial # _____

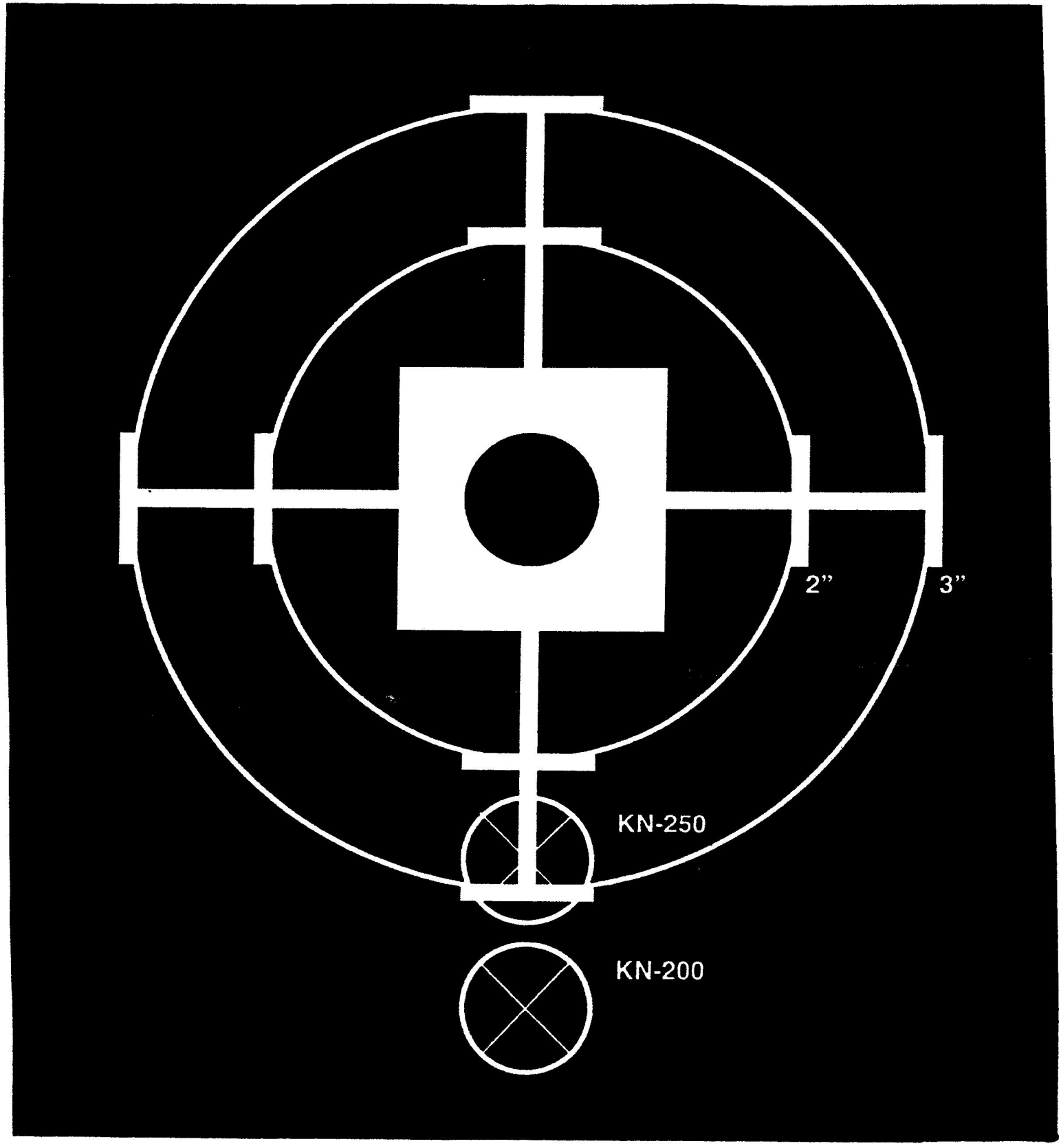
FACE 3 TARGET



Name _____
Date _____
Rifle Serial # _____

FACE 4 TARGET





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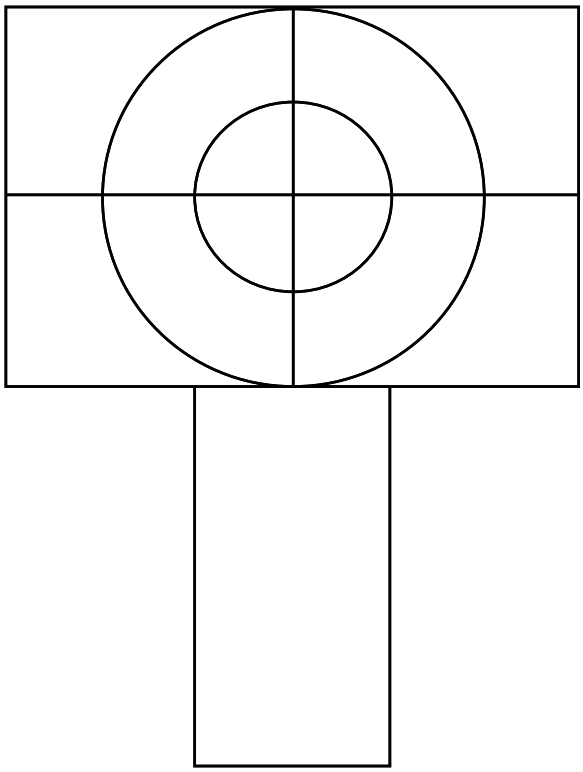
PH. 954 568-7690 FX. 954 630-4159

SIMRAD Optronics

T-ZONE
FACE TARGET MEASUREMENT TEMPLATE



Print Or Copy Onto Transparency Paper For Range Use

SHOT MATRIX

RANGE (YARDS)

TEMPERATURE	50	100	150	200	250	300	350	400	450	500	550	600
50°												
55°												
60°												
65°												
70°												
75°												
80°												
85°												
90°												
95°												
100°												
105°												
110°												

Weapon: **Scope:** **Ammunition:** **Location:**

SHOT MATRIX

RANGE (YARDS)

TEMPERATURE	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
50°												
55°												
60°												
65°												
70°												
75°												
80°												
85°												
90°												
95°												
100°												
105°												
110°												

Weapon: **Scope:** **Ammunition:** **Location:**

RANGE (YARDS)

TEMPERATURE	50	100	150	200	250	300	350	400	450	500	550	600
50°												
55°												
60°												
65°												
70°												
75°												
80°												
85°												
90°												
95°												
100°												
105°												
110°												

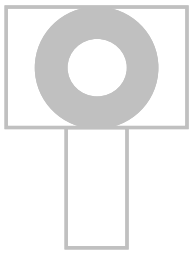
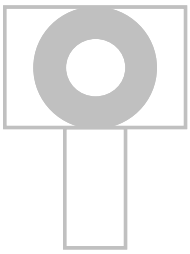
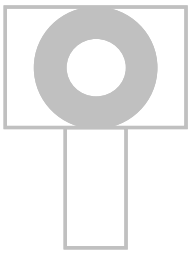
Weapon: **Scope:** **Ammunition:** **Location:**

RANGE (YARDS)

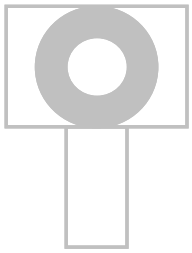
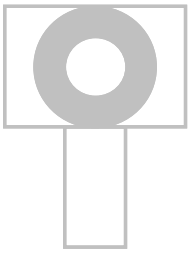
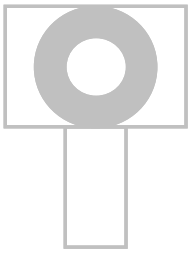
TEMPERATURE	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
50°												
55°												
60°												
65°												
70°												
75°												
80°												
85°												
90°												
95°												
100°												
105°												
110°												

Weapon: **Scope:** **Ammunition:** **Location:**

COLD-BORE ANALYSIS

ELEV:	WIND:	ELEV:	WIND:	ELEV:	WIND:
					
DATE:		DATE:		DATE:	
RANGE:		RANGE:		RANGE:	
TEMP:		TEMP:		TEMP:	
ALTITUDE:		ALTITUDE:		ALTITUDE:	
AMMUNITION:		AMMUNITION:		AMMUNITION:	
CONDITIONS:		CONDITIONS:		CONDITIONS:	

COLD-BORE ANALYSIS

ELEV:	WIND:	ELEV:	WIND:	ELEV:	WIND:
					
DATE:		DATE:		DATE:	
RANGE:		RANGE:		RANGE:	
TEMP:		TEMP:		TEMP:	
ALTITUDE:		ALTITUDE:		ALTITUDE:	
AMMUNITION:		AMMUNITION:		AMMUNITION:	
CONDITIONS:		CONDITIONS:		CONDITIONS:	

COLD-BORE ANALYSIS

ELEV:	WIND:	ELEV:	WIND:	ELEV:	WIND:
DATE:		DATE:		DATE:	
RANGE:		RANGE:		RANGE:	
TEMP:		TEMP:		TEMP:	
ALTITUDE:		ALTITUDE:		ALTITUDE:	
AMMUNITION:		AMMUNITION:		AMMUNITION:	
CONDITIONS:		CONDITIONS:		CONDITIONS:	

COLD-BORE ANALYSIS

ELEV:	WIND:	ELEV:	WIND:	ELEV:	WIND:
DATE:		DATE:		DATE:	
RANGE:		RANGE:		RANGE:	
TEMP:		TEMP:		TEMP:	
ALTITUDE:		ALTITUDE:		ALTITUDE:	
AMMUNITION:		AMMUNITION:		AMMUNITION:	
CONDITIONS:		CONDITIONS:		CONDITIONS:	

COLD-BORE ANALYSIS

ELEV:	WIND:	ELEV:	WIND:	ELEV:	WIND:
DATE:		DATE:		DATE:	
RANGE:		RANGE:		RANGE:	
TEMP:		TEMP:		TEMP:	
ALTITUDE:		ALTITUDE:		ALTITUDE:	
AMMUNITION:		AMMUNITION:		AMMUNITION:	
CONDITIONS:		CONDITIONS:		CONDITIONS:	

COLD-BORE ANALYSIS

ELEV:	WIND:	ELEV:	WIND:	ELEV:	WIND:
DATE:		DATE:		DATE:	
RANGE:		RANGE:		RANGE:	
TEMP:		TEMP:		TEMP:	
ALTITUDE:		ALTITUDE:		ALTITUDE:	
AMMUNITION:		AMMUNITION:		AMMUNITION:	
CONDITIONS:		CONDITIONS:		CONDITIONS:	

COLD-BORE SHOT

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12, 3, 6, 9)	SPEED: STEADY / GUSTY		LIGHT (12, 3, 6, 9)			
MIRAGE	COMMENTS					
TARGET PAGE NUMBER	NOTES			CALL		

COLD-BORE SHOT

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12, 3, 6, 9)	SPEED: STEADY / GUSTY		LIGHT (12, 3, 6, 9)			
MIRAGE	COMMENTS					
TARGET PAGE NUMBER	NOTES			CALL		

COLD-BORE SHOT

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION	SPEED		LIGHT			
MIRAGE	COMMENTS					
TARGET PAGE NUMBER	NOTES			CALL		

STEADY

GUSTY

COLD-BORE SHOT

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION	SPEED		LIGHT			
MIRAGE	COMMENTS					
TARGET PAGE NUMBER	NOTES			CALL		

STEADY

GUSTY

COLD-BORE SHOT

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION 12 9 3 6	SPEED STEADY GUSTY		LIGHT 12 9 3 6			
MIRAGE	COMMENTS					
TARGET PAGE NUMBER	NOTES			CALL		

COLD-BORE SHOT

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION 12 9 3 6	SPEED STEADY GUSTY		LIGHT 12 9 3 6			
MIRAGE	COMMENTS					
TARGET PAGE NUMBER	NOTES			CALL		

2" BULLSEYE TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

2" BULLSEYE TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

3" BULLSEYE TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

3" BULLSEYE TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

1" CROSSHAIR INDICATOR

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

1" CROSSHAIR INDICATOR

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

6" BULLSEYE TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

6" BULLSEYE TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

1" DIAMOND TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

1" DIAMOND TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION (12 / 9 / 3 / 6)	SPEED: STEADY / GUSTY		LIGHT (12 / 9 / 3 / 6)			
MIRAGE	COMMENTS					

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

IPSC SILHOUETTE

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

IPSC SILHOUETTE

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

TQ-15

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 / 9 / 3 / 6		STEADY / GUSTY	12 / 9 / 3 / 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

TQ-15

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 / 9 / 3 / 6		STEADY / GUSTY	12 / 9 / 3 / 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

FACE 1

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

FACE 1

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

FACE 2

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

FACE 2

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

FACE 3

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

FACE 3

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

FACE 4

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

FACE 4

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			

WIND DIRECTION	SPEED	LIGHT
12 / 9 / 3 / 6	STEADY GUSTY	12 / 9 / 3 / 6

MIRAGE	COMMENTS

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

HEAD TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

HEAD TARGET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

LEFT PROFILE

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

LEFT PROFILE

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

RIGHT PROFILE

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

RIGHT PROFILE

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	CALL					

DATA SHEET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

DATA SHEET

DATE	WEAPON		SCOPE	HOLD	CORRECT ELEVATION	CORRECT WINDAGE
RANGE	TEMP	ALTITUDE	AMMUNITION			
WIND DIRECTION		SPEED	LIGHT			
12 9 3 6		STEADY / GUSTY	12 9 3 6			
MIRAGE		COMMENTS				

TARGET PAGE NUMBER	SHOT	1	2	3	4	5
	ELEV					
	WIND					
	C A L L					

BALLISTIC SET TABLE

M/O TEAM:	DATE:	TIME:	INCIDENT:

AMMUNITION:	RIFLE:	PAGE: of

TARGET	GRID	RANGE	ANGLE	HOLDOFF	SIGHT CHANGES	NOTES

BALLISTIC SET TABLE

M/O TEAM:	DATE:	TIME:	INCIDENT:

AMMUNITION:	RIFLE:	PAGE: of

TARGET	GRID	RANGE	ANGLE	HOLDOFF	SIGHT CHANGES	NOTES

FIELD SKETCH

Observer Name: _____ **Date/Time:** _____

Sketch Name: _____ **Location:** _____

N

REMARKS	SKETCH

OBSERVATION LOG

Observer Name: _____ **Date/Time:** _____

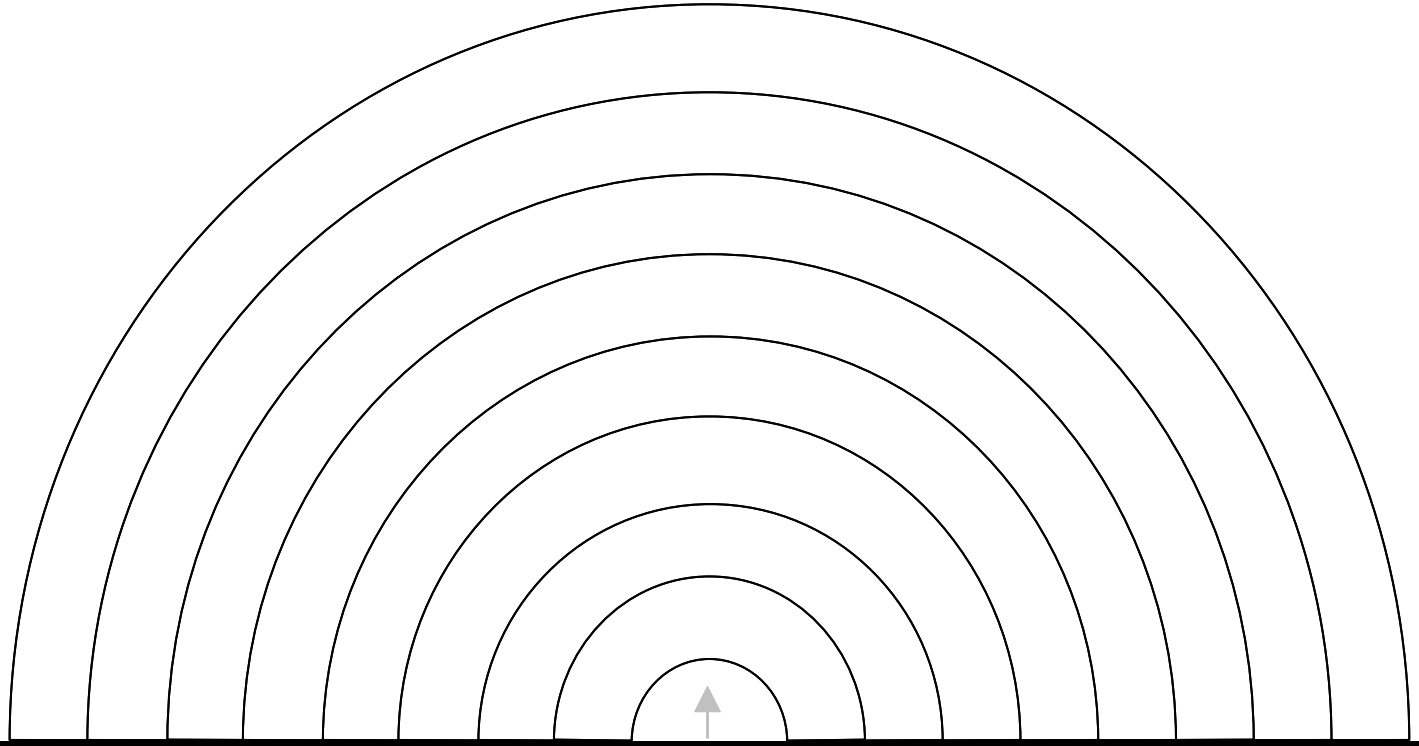
Light Conditions: _____ **Visibility:** _____

N

ITEM #	TIME	GRID LOCATION	OBSERVATION / EVENT	ACTIONS TAKEN

RANGE CARD

NAME	RANGING METHOD



RANGE																		RANGE
ELEVATION																		ELEVATION
WINDAGE																		WINDAGE

TEMPERATURE		WIND	
HIGH	LOW	VELOCITY	DIRECTION

COMMENTS

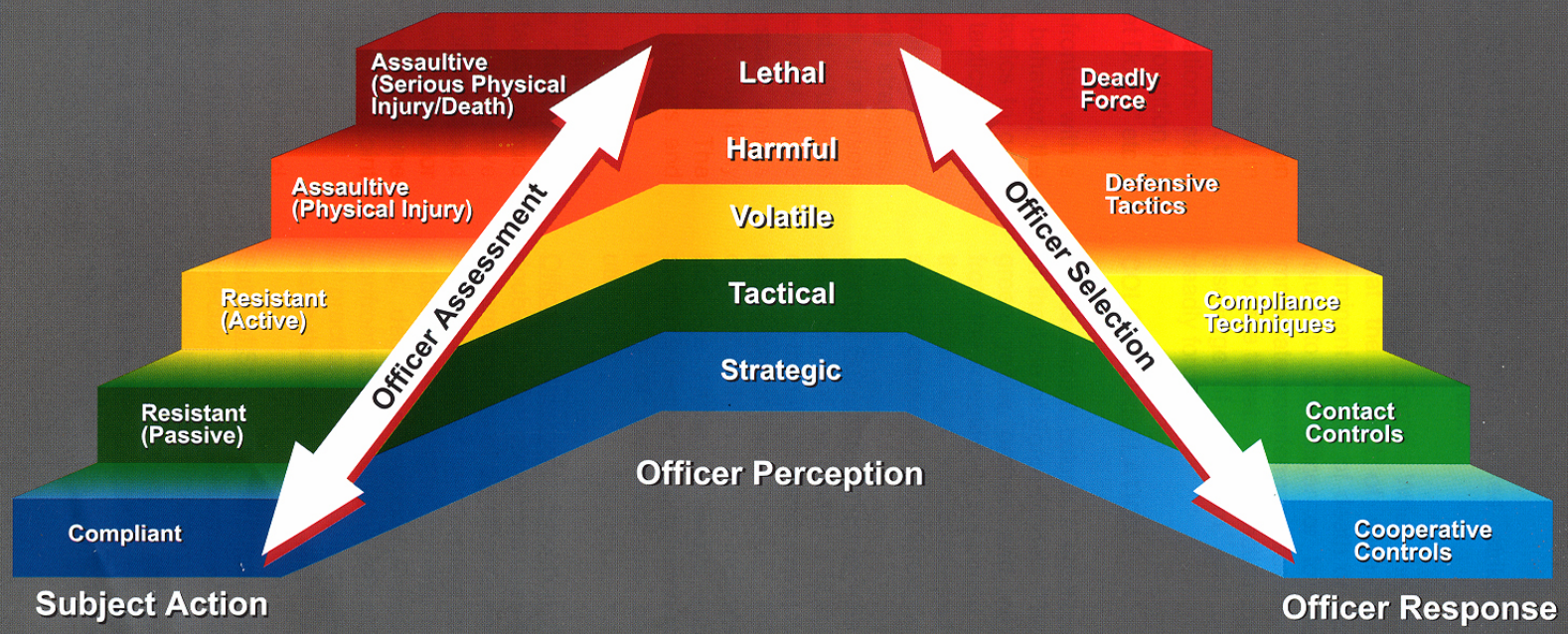
ROUND COUNT

DATE	LOT NUMBER	ROUNDS FIRED	TOTAL FIRED	DATE	LOT NUMBER	ROUNDS FIRED	TOTAL FIRED

POLICY REMOVED FOR OUTSIDE DISTRIBUTION

Federal Law Enforcement Training Center

Use of Force Model



4/99

USBP PM/O
QUALIFICATION COURSE

Ammo: 21 Rounds **Range:** 100-500 yards **Target:** Face Targets, TQ-15

COLD-BORE SHOT

RANGE: 100 yards

ROUNDS: 1

TARGET: Face 1

COURSE OF FIRE: The shooter will ground an empty weapon with the bolt open. Upon command, the shooter will move to a prone supported position and load and fire one shot through a cold bore within 1 minute. The shot must strike the T-Zone outlined on the Face 1.

TIME LIMIT: 1 minute

SHOT GROUP

RANGE: 100 yards

ROUNDS: 4

TARGET: Face 2

COURSE OF FIRE: From a supported prone position, the shooter will fire four rounds at the Face 2 Target. All four rounds must strike the 2-inch zone outlined on the Face 2.

TIME LIMIT: None

STRESS FIRE

RANGE: 100 yards

ROUNDS: 4

TARGET: Face 3

COURSE OF FIRE: The shooter will ground a weapon with the bolt open and four rounds in the magazine. At the START command, the shooter will run/jog 200 yards, and then assume a prone supported position behind the weapon. Upon command, the shooter will fire four rounds within 1 minute. All four shots must strike the defined zone outlined on the Face 3.

TIME LIMIT: 1 minute

POSITION SHOOTING

RANGE: 100 yards

ROUNDS: 4

TARGET: TQ-15

COURSE OF FIRE: The shooter will begin with the weapon loaded, on safe, and in a low rifle position. Upon command, the shooter will fire one round from the standing position. After firing the first round, the shooter will have 1 minute to fire a second round from the standing position, move to a sitting or kneeling position, and fire two additional rounds. All four rounds must strike the Five-Ring of the TQ-15 Target.

TIME LIMIT: 1 minute from first shot

200-YARD FACE SHOT

RANGE: 100 yards

ROUNDS: 2

TARGET: Face 4

COURSE OF FIRE: From a supported prone position, the shooter will fire two rounds at the Face 4 Target. Both rounds must strike the defined zone outlined on the Face 4.

TIME LIMIT: None

300-YARD BODY SHOT

RANGE: 300 yards

ROUNDS: 2

TARGET: TQ-15

COURSE OF FIRE: From a supported prone position, the shooter will fire two rounds at a TQ-15 Target. Both rounds must strike the "5" scoring zone of the TQ-15.

TIME LIMIT: None

400-YARD BODY SHOT

RANGE: 400 yards

ROUNDS: 2

TARGET: TQ-15

COURSE OF FIRE: From a supported prone position, the shooter will fire one round at a TQ-15 Target. The shooter will have one follow-up shot. One of two rounds must strike the "5" scoring zone of the TQ-15 Target.

TIME LIMIT: None

500-YARD BODY SHOT

RANGE: 500 yards

ROUNDS: 2

TARGET: TQ-15

COURSE OF FIRE: From a supported prone position, the shooter will fire one round at a TQ-15 Target. The shooter will have one follow-up shot. One of two rounds must strike the "5" scoring zone of the TQ-15 Target.

TIME LIMIT: None

USBP M4 QUALIFICATION COURSE

Ammo: 50 Rounds **Range:** 100, 25, 15, 7 yards **Target:** TQ-15, TQ-15R

100-YARD LINE

ROUNDS: 15

MAGAZINE PREP: 1 X 15

MODE OF FIRE: Semi-automatic

COURSE OF FIRE: Shooter's choice of standing, kneeling, sitting, or prone. Five rounds must be fired from three different positions. Two strings of fire must be performed from behind cover. One string of fire must be performed from behind cover using the weak side.

TIME LIMITS: 2 minutes for each five-round string.

NOTE: For a reduced range of 50 yards, the TQ-15R target will be used to simulate 100 yards.

25-YARD LINE

ROUNDS: 10

MAGAZINE PREP: 1 X 10

MODE OF FIRE: Semi-automatic

COURSE OF FIRE: From the high ready position, shooter will fire 2 rounds each facing or command for a total of 6 rounds. From the high ready position, shooter will kneel and fire 2 rounds each string or facing for a total of 4 rounds. Shooter will start with the weapon on safe and manipulate the safety each string.

TIME LIMITS: 4 seconds for standing position and 5 seconds for kneeling position.

15-YARD LINE

ROUNDS: 10

MAGAZINE PREP: 1 X 6, 1 X 4

MODE OF FIRE: Full-automatic

COURSE OF FIRE: From the high ready position, shooter will fire 2-round bursts until the weapon is empty, reload and fire 2-round burst until the weapon is empty for a total of 10 rounds.

TIME LIMIT: 15 seconds to fire both magazines.

7-YARD LINE

ROUNDS: 15

MAGAZINE PREP: 1 X 15

MODE OF FIRE: Full-automatic

COURSE OF FIRE: From the high ready position, shooter will fire 3-round burst each facing or command for a total of 15 rounds.

TIME LIMIT: 2 seconds for each facing (5 facings or commands).

MAXIMUM SCORE: 250
MINIMUM PASSING SCORE: 170

USBP M14 QUALIFICATION COURSE

Ammo: 60 Rounds **Range:** 100, 50, 25, 15, 7 yards **Target:** TQ-15, TQ-15R

100-YARD LINE

ROUNDS: 20

MAGAZINE PREP: 1 X 20

COURSE OF FIRE: Shooter will start at the port arms position. When the target faces or the command is given, the shooter will fire 5 rounds standing, 5 rounds kneeling, 5 rounds sitting, and 5 rounds prone.

TIME LIMIT: No time limit

NOTE: For a reduced range of 50 yards, the TQ-15R target will be used to simulate 100 yards.

50-YARD LINE

ROUNDS: 10

MAGAZINE PREP: 1 X 10

COURSE OF FIRE: Shooter will start aimed in on his target from the gun-side barricade position. When the target faces or the command is given, the shooter will fire 5 rounds from the gun-side barricade position and then 5 rounds from the non gun-side barricade position.

TIME LIMIT: No time limit

NOTE: For a reduced range of 50 yards, the TQ-15R target will be used to simulate 100 yards.

25-YARD LINE

ROUNDS: 10

MAGAZINE PREP: 1 X 6, 1 X 4

COURSE OF FIRE: From the port arms or hip level position, the shooter will fire 2 rounds each facing or command for a total of 6 rounds. From the low ready position, shooter will kneel and fire 2 rounds each string or facing for a total of 4 rounds. Shooter will start with the weapon on safe and manipulate the safety each string.

TIME LIMIT: Standing – 4 seconds each facing, kneeling – 5 seconds each facing

15-YARD LINE

ROUNDS: 10

MAGAZINE PREP: 2 X 5

COURSE OF FIRE: From the port arms or hip level position, the shooter will fire 5 rounds, kneel and reload, and then fire 5 rounds from the keeling position.

TIME LIMIT: 20 seconds

7-YARD LINE

ROUNDS: 10

MAGAZINE PREP: 1 X 10

COURSE OF FIRE: From the ready rifle position, the shooter will fire 5 rounds from his gun-side shoulder. Shooter will transition the rifle to his non gun-side shoulder. From the ready rifle position, the shooter will fire 5 rounds from his non gun-side shoulder.

TIME LIMIT: 3 seconds gun-side, 4 seconds non gun-side

MAXIMUM SCORE: 300
RATINGS: Master-295, Expert-285, Sharpshooter-255, Marksman-210